Impacts of digital feedback on the precursors of behaviour change

Behave 2018

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Behave 2018: An inspiring debate

Openings and Keynotes

In September 2018, more than 300 participants debated the perspectives of energy policy transition and implementation of sustainable energy technologies. At Behave 2018 (Conference on Behaviour and Energy Efficiency) in Zurich, the internationality and the interdisciplinarity of scholarship in the field were surprising and inspiring.

The President of the Zurich University of Applied Sciences, **Jean-Marc Piveteau**, opened the conference by referring to the development of the ZHAW into one of the leading competence centres of applied sciences in the field of energy research in Europe. **Benjamin Sovacool**, Editor of "Energy Research & Social Sciences", made a strong claim for research designs that refuse "discliplinary chauvinism" and "theoretical monogamy". From his point of view, energy research can and should be more oriented towards real world problems and thus have to deal not only with theory, but also with policy relevance and application. The other keynote speakers were **Marianne Zünd** (Swiss Federal Office of Energy) and **Marylin Mehlman** (Co-Founder of Legacy 17). They outlined the complex and sometimes curious paths of social change towards more sustainable energy behaviours. Those paths lead us into the value systems of concerned citizens (Mehlman) and into the complex processes of democratic systems in the western world (Zünd).

On the Built Environment

Sustainability and environmental policies that increasingly target the building sector may explain why a lot of studies presented at Behave 2018 were devoted to understanding and changing behaviour related to energy use and CO_2-emissions of buildings. While most research still focusses on the individual energy-relevant behaviour of private citizens, there is a small but growing interest in the decisions and actions of institutional building-owners and building professionals. Energy feedback, gamification, nudging, promoting acceptance and adoption of new technologies, science-city collaboration, alternative policies and business models were among the solutions discussed to support the energy transition.

On the Public Sphere

Within the framework of the sessions that were dedicated to communication sciences and discourse studies, scholars from all over Europe presented their investigations of media coverage, stakeholder expectations and goals, and systemic effects of focussed communication efforts. These sessions clearly showed that the challenge of changing behaviours cannot be faced by marketing measures or other isolated strategic measures. It's rather about curating the common sense, deliberating citizens' value systems and letting society participate in the huge project of policy transition.

On Interventions and Feedback

Much of the conference dealt with interventions concerning how to change humans' behaviour towards more environmentally friendly actions in different sectors. A total of three different parallel sessions addressed humans' behaviour and households. The importance of feedback was also considered in many talks during the conference. Last but not least, a session of several talks was dedicated to the transportation sector, which accounts for a large quantity of CO2-emissions.

With more than 30 sessions on these and other subjects and numerous personal discussions of the participants on the margins of the conference, Behave 2018 was a huge success. The members of the organising committee thank all participants, visitors, partners, the media and the ZHAW for their support that made this success possible.

See you at Behave 2020!

Abstracts

THE ROLE OF THE USER IN PEER-TO-PEER ENERGY COMMUNITIES

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Keywords: Renewables, P2P energy markets, user experience, user interface, sustainability

1. MOTIVATION

The depletion of natural resources and increasing energy demand [1] highlight the need for innovative approaches that tackle issues of energy security, uncertainties of energy prices, and environmental sustainability – the so-called energy trilemma [2]. With decreasing costs and technological progress, decentral energy resources (DER) increasingly become a promising renewable alternative to fossil fuels and are considered a backbone of future power systems (e.g. 'Energiestrategie 2050' in Switzerland [3], 'Renewable Energy Directive' in the European Union [4]). Yet, DER like wind and solar power cannot follow a demand-sided production plan. In fact, the future power system in many countries is facing a rather asynchronous production and demand pattern, with DERs producing energy during the day while peak demand occurs in the mornings and evenings and storing energy is still expensive. These developments have caused a paradigm shift, granting once passive consumers a new role as potentially more active market participants: in particular, they may become 'prosumers' by investing in DER and storage technologies. In many regions, prosumers can feed excess energy into the grid in exchange of a monetary compensation. Yet, while electricity retail prices are rising, prosumers are increasingly facing falling feed-in tariffs in many countries. These developments make solutions more and more attractive that allow local trading of electricity among prosumers and consumers without intermediaries – so-called peer-to-peer (P2P) networks. In practice, such P2P networks are still in their infancy. Aside from technical and regulatory challenges, the key challenge is yet to engage consumers in this transformation, as electricity is a low-involvement commodity which is invisible and taken for granted by most consumers [5].

2. BUILDING A PROTOTYPE OF A PEER-TO-PEER ELECTRICITY NETWORK

To investigate the feasibility and real-world challenges of such a P2P system, we are currently building a real-world prototype of a P2P electricity network, which allows prosumers to market the electricity produced by their PV system to their community peers. The project has been approved for funding as a lighthouse project by the Swiss Federal Office of Energy and will be implemented in the town of Walenstadt (SG) in collaboration with the local utility company and several other partners from industry and academia. In this project, a minimum of 20 households will have the possibility to produce, consume and exchange locally generated electricity on a local market in their neighborhood. Energy exchange with the higher grid levels only occurs during times when the community is not self-sufficient or is producing more energy than consumed. Each household will be equipped with a smart meter that tracks electricity consumption and production. A virtual trading agent matches demand and supply, calculates the current market prices and stores the transactions in the blockchain. In addition, we develop a user interface in which the participants can set their trading preferences and monitor the status of their electricity supply (and, in the case of prosumers, of their electricity sales). Developing that user interface is a key component in this project. In fact, user engagement has revealed itself as more difficult and critical to the success or failure of many demand side management programs in the past few years than technical aspects [6]. Therefore, we carefully evaluate different content and design alternatives in a structured and iterative process.

3. IMPORTANCE OF USER INTERACTION

By design, consumers and prosumers play a central role in our prototype: they ensure the direct consumption of locally produced electricity within the community. Both, consumers and prosumers, can contribute to the self-sufficiency of the community by buying or selling local electricity. Prosumers may increase the profitability of their investments into PV systems or batteries by selling electricity at a higher price within the community than they might expect from feed-in tariffs in the future. Thus, P2P networks can make investments into additional DER more economically attractive, helping to increase the share of DER in the long term. Community members may also invest jointly in local infrastructure like a communal battery storage with associated dividends for the investors (crowdfunding). Examples like the success of Zurich utility company's product 'Lettenstrom' reveal that a considerable share of consumers has a higher willingness to pay for clean, locally produced energy. To what extent this can be leveraged on a larger scale in P2P networks and what kind of user interface facilitates the increase of local investments needs to be investigated. In our project, participants will have access to two user interfaces that enable an active participation in the project: a webapp and a message bot. The webapp features five functionalities: (1) community: statistics about the community's autarky, community building, (2) market: option to set buy and sell prices for local electricity, (3) transparency: production and consumption values in real-time and historic, (4) electricity billing: overview about financial transactions, and (5) investments: customer- and community-specific profitability estimations of installing solar panels or batteries. Given the relatively low engagement of end consumers with such technologies on the long-term in many previous projects [7], we provide the users with additional feedback on community statistics and individual market activity via a Whatsapp message bot and remind them to return to the webapp occasionally. Both user interfaces are developed in an iterative process following a product development framework from Human-Computer-Interaction research [8]. This includes frequent user feedback in early stages which we obtain by interviewing potential users in a first step, by conducting focus groups to get user feedback on following wireframes and by intensive usability testing while implementing the application.

4. CONCLUSION

In this project, we build a prototype of a P2P energy market in which participants can trade electricity locally. A central component of the project is the development of the user interface. To that end, we will investigate to what extent different kinds of content motivate consumers and prosumers to engage with the platform and local community.

ACKKNOWLEDGEMENTS

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Macroergonomics: A Path to Understanding Zero Energy Builder-developers

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Keywords: Middle actors, Zero energy buildings, Macroergonomics, Sociotechnical Systems

1. INTRODUCTION

Buildings continue to have a large impact on the environment, consuming 20% of worldwide energy (40% of U.S. energy) [1]. Zero energy housing (ZEH) is considered a solution toward reducing global energy demand and emissions. A ZEH is defined as a housing unit that produces as much energy on site (typically using solar photovoltaic systems) as it consumes on an annual basis [2],[3]. To deliver this level of performance, a ZEH relies on an integrated team and systems approach (including and extending to human-system integration), yet existing literature often neglects the role of middle actors in the design, development, and delivery of ZEH. Middle actors, such as builder-developers, are important stakeholders since they shape the built environment and can serve as a catalyst for reducing global carbon emissions [4]. How can we begin to optimize the role and behavior of middle actors toward the delivery of ZEH housing? Macroergonomics approaches may afford new perspectives to further the positive influence of middle actors in the built environment.

Macroergonomics is the sociotechnical systems-based study and design of work systems. Macroergonomics evaluates and seeks to optimize organization-system interactions with technology within an organizational system [5]. The aim of this work is to understand the behavior outcomes impacted by two common organizational design and construction delivery methods; design-build and design-bid-build. Specifically, this study evaluates two builder-developer middle actor organizations engaged in the development of ZEH in the United States.

Builder-developers play a critical role in zero energy housing; transforming financial and intellectual capital into housing units. In the context of this work, builder-developer organizations are structured in cross-functional teams that work toward producing ZEH. The builder-developer's organization system interacts with teams both internal and external to the organization. The For example, design consultants also play a role in system success, hopefully through the lens of the organizational vision. Asset managers and property maintenance staff are on the output side of the system and have considerable insight to system successes and irregularities, yet in the author's experience asset staff are often not utilized as critical feedback mechanisms. Alignment across mission, vision, and values through performance expectations, function allocation, role networks, jobs, personnel and training are critical for organizational and system success. Simply put, sub-optimal organizational behavior can result from poorly designed organizational systems and negatively impact ZEH goals and middle actor outcomes.

2. ANALYSIS

The authors compared two ZEH development case study projects, developed by two builder-developers (BD-1 and BD-2) located in Virginia, USA. Zero energy performance was evaluated as well as the builder-developers as middle actors. The ten phase Macroergonomics Analysis and Design (MEAD) method was employed to evaluate opportunities for middle actors engaged in the ZEH market to optimize their behavior through the design of their work system. The first three phases of the MEAD analysis can be found in table 1.

Table 1. Macroergonomics Analysis and Design (MEAD) input to understand middle-actor system behavior

MEAD Phase		Builder-developer 1	Builder-developer 2
1. Scanning Analysis	Organization Type	Non-profit	Non-profit
	Organizational Mission	"To create homes and communities that are healthy, sustainable, and affordable."	"The builder-developer 2* changes lives and transforms communities through high-quality, affordable housing."
2. System type & performance analysis	Team Structure & Delivery Method	Design-build	Design-bid-build
	Housing Type	Rental, Senior	Rental, Senior
	Mean Energy Use Intensity (kBtu/m^2/yr)	-0.14	15.82
	Direct Cost/Apartment	\$115,542	\$121,441
3. Technical work process & unit operations	Builder-developer resident program	Resident education program	No resident education program

*Organization name removed for privacy.

3. PRELIMLINARY FINDINGS

The authors developed the following conclusions as a result of this work:

1. Zero energy builder-developers are important middle actors;
2. Design-build projects demonstrate improved team behavior and project outcomes compared to design-bid-build teams;
3. Design-build teams are integrated, with common goals, resulting in reduced transaction costs and better performance records.

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END-USE ELECTRICITY CONSUMPTION PROFILES OF TURKISH HOMES

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Keywords: Electrical appliances, Household electricity consumption, Hourly Load Profiles

1. INTRODUCTION

The electricity consumption of Turkey has increased at a high rate of about 5% per year since 2000. The residential sector accounts for almost one fourth of the total electricity consumption in Turkey. Due to increase in household income levels and decrease in the costs of electrical household appliances in recent years, a rapid increase in the number of household appliances has been observed. The majority of the electricity consumed at Turkish homes is due to the use of appliances and lighting. Thus, determining the magnitude and time of use of the electricity consumption of the appliances and lighting, and factors affecting the consumption of these end-uses will play an important role in determining the applicable energy conservation measures and potential savings for this sector.
Since 1980's, various end-use load monitoring campaigns had been conducted to determine the hourly profile of various appliances at homes [1-3]. In addition to monitoring specific end-uses, indoor and outdoor temperatures were also recorded and weather sensitivities of the end-uses were studied in some studies [4, 5]. To determine the effect of behaviour and socio-economic characteristics of the occupants on the appliance usage profile, in addition to the monitored end-use electricity consumption data, survey data were also used in some studies [6-8].
In this study, it is aimed to develop hourly load profiles of some specific appliances based on various day types for Turkish homes and to determine the relationship between the appliance electricity consumption and socio-economic characteristics of the occupants. These profiles would provide information on when the maximum usage of specific end-uses occurs, and which end-uses are ''behaviour based'' and which are ''outdoor temperature based".

2. METHODOLOGY

In the first stage of the study, survey with 45 questions are conducted at 30 homes and specific appliances at these homes are monitored for 10-min intervals using wattmeters and pulsemeters between July and December 2016. In the second stage of the study, the refrigerator, dishwasher, television, clothes washer hourly data of the homes are categorized and average hourly loads are determined based on eight day types, which are summer (between May 1st and October 31st), winter (between November 1st and April 30th), weekday, weekend-holiday, summer weekday, summer weekend-holiday, winter weekday, and winter weekend-holiday. In the last stage of the study, one-way ANOVA tests are conducted to determine the effect of square footage, home ownership, number of occupants, and household income factors on appliance electricity consumption.

3. RESULTS

The hourly load profiles of dishwasher, clothes washers, televisions, and refrigerators are analysed based on eight day-type categories. The results show that there are not clear distinctions between day type categories of dishwasher and clothes washer load profiles; however, the refrigerator hourly load profile for winter, winter weekend-holiday, and winter weekday categories are found to be lower than those of the other summer day type categories. This shows that the refrigerator hourly load profile can be considered as an ‘‘outdoor temperature based end-use’’ since it exhibits lower usages at winter day type categories. On the other hand, the television hourly load profile can be considered as a ‘‘behaviour based end-use’’, since its load profiles exhibit high values for weekend-holiday day type categories, when most homeowners are at home. The average household annual clothes washer, television, dishwasher, and refrigerator electricity consumptions are determined as 121, 125, 134, and 684 kWh/year, respectively, assuming that monitored period is representative for the whole year. These results are in agreement with those determined from a survey study conducted in 2014 in Ankara [9]. The one-way ANOVA results show that categorized consumption data represented for each socio-economic factors are independent from each other; and clothes washer, refrigerator, and television electricity consumptions increase as the number of occupants, household income, and home ownership increase, respectively.

4. CONCLUSIONS

This study analyses the hourly load profiles of major appliance at Turkish homes. The profiles are examined based on their tendencies towards outdoor temperature or behavioural dependencies. As expected, the hourly load profiles categorized based on day types present that television usage is higher on weekend-holidays and refrigerator usage is higher on summer days. The highest average annual consumption is determined for refrigerators among four monitored appliances. Thus, energy saving policies should be focused on reducing the refrigerator consumption, which will be higher on summer days. Also, owner occupied and high income home with high number of occupants have high television, refrigerator, and clothes washer electricity consumptions, respectively.

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Reaching the hardest to reach in energy advice and support: key lessons and good practice from the UK

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Keywords: energy poverty, interventions, vulnerability

1. INTRODUCTION

This paper will draw on the emerging findings of a research project which identified good practice and lessons to make future fuel poverty and home energy efficiency initiatives work better for those in society most in need of lower energy costs and warmer, healthier homes. The project is led by Sheffield Hallam University in partnership with leading UK charity Citizens Advice (CA) and two energy companies. It also directly involved 20 organisations from across the advice, energy and academic sectors. Critically, the project engaged with 40 vulnerable and hard to reach citizens (VHR). Data collection and consultation are still ongoing but some emerging insights are shared at this conference as a stimulus for debate.

2. PROJECT AIMS AND OUTCOMES

Ensuring that policies and interventions intended to alleviate fuel poverty and improve domestic energy efficiency benefit those who need them most is critical to improving the health, wellbeing and social and financial circumstances of the most vulnerable in society. There is little existing academically ratified knowledge or good practice to draw on in addressing this challenge (see Ambrose et al, 2016[i]). We are assured by our partners that a project of this nature is much needed, as demonstrated by the following comment: *"There is- without a doubt- a great need for information about targeting the most vulnerable and most invisible households. So many organisations seem to be struggling with it at the same time, so I applaud this initiative."* (Email from representative of HUBBUB, 26th October, 2016).

The project-funded by the Higher Education Innovation Fund- began in 2017 at a time when fuel poverty and domestic energy efficiency policies were being overhauled in the UK, boosting scope for policy influence. The project (ongoing) will yield good practice principles regarding the successful engagement of society's most VHR households in energy initiatives. This knowledge will also be critical in enabling energy and advice providers to work together to exploit the best opportunity in decades to engage face to face in the homes of every VHR household in the UK through the installation of smart meters.

Intended impacts of the project include:

- Improved ability on the part of the advice and energy sectors to engage meaningfully with and improve the circumstances of VHR groups on energy issues as well as reaching those not previously reached
- The advice and energy sectors find new ways of working together on home energy efficiency.

[i] Ambrose, A., Damm, C., Foden, M., Gilbertson, J. and Pinder, J. (2016) *Delivering Affordability Assistance to water customers: cross sector lessons*. Sheffield: CRESR, Sheffield Hallam University.

- Increases in the number of VHR households benefitting from access to energy advice and support. More of those not previously engaged with are reached.
- Changes to policy and strategy to reflect new knowledge on how to engage with these groups on energy issues. These changes will be visible within the policies and strategies of participating organisations sooner than influence will be seen at a national level.
- Reductions in fuel poverty amongst VHR households and associated improvements in health, wellbeing and financial and social inclusion.

3. METHODS

These aims will be achieved through, *inter alia*, a review of existing published evidence in addition to consultation with stakeholders and citizens to establish 'what works best, for whom and under what circumstances' in terms of meaningfully engaging the most VHR in society in energy advice and support. The project will yield good practice principles and policy recommendations developed with the advice and energy sectors and tested with citizens. The following activities have been conducted or are underway:

- A baseline evidence review: who has been reached by previous policies and interventions? Who has been missed? What do we already know about what works?
- The generation of new knowledge through consultation with those working with VHR citizens.
- Directly consulting VHR citizens about what works for them (via specially convened Citizens Panels), barriers to engagement and to test the viability and sensitivity of good practice principles and recommendations emerging from the project

4. CONCLUSIONS

Emerging findings and draft recommendations from the project are under development and will be shared at the conference. The project has already broken new ground by:

- bringing together the advice, energy, policy and academic communities with citizens to identify the best ways of engaging society's most VHR in energy advice and support.
- directly engaging VHR groups in the development of recommendations through Citizens Panels.

Intended project outcomes include:

- Policy making and policy initiatives are more sensitive to the needs of the VHR and based on sound evidence regarding what works well, for whom and under what circumstances. Advice and support services and initiatives that reach more of those who need them the most and respond to the needs of VHR groups.
- Advice, energy and policy sectors are united around a set of good practice principles for engaging VHR groups and are ready to work together.
- A clearer sense of how the opportunities for engagement afforded by the UK smart-meter roll out might be exploited for the benefit of VHR consumers.

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BEHAVIOURAL ASPECTS REGARDING ALTERNATIVE VEHICLE AND FUEL CHOICES

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Keywords: Consumer choice, Alternative fuelled vehicles, Alternative fuels, Behavioural economics

INTRODUCTION AND AIM

The transport sector is facing big challenges, considering that the sector is largely dominated by fossil fuels and therefore contributes substantially to global carbon dioxide emissions. Of the European vehicle fleet for passenger cars alternative fuel vehicles (AFVs) constitute less than 4 percent [1]; cars running on petrol or diesel thus still prevail. To deal with the negative impacts on the environment, and increase the sustainability of the transport sector, changes are needed. Replacing fossil fuels with renewable fuels is one way to reduce climate impacts from personal transportation, and new techniques and alternative fuels have been introduced in past years. Nevertheless, in view of the low number of AFVs in total, consumers are still choosing cars that run on traditional fuels.

The choices of vehicle and fuel are interrelated but represent two different choices. The choice of fuel used to be incorporated in the choice of vehicle, but new technique has introduced this choice for consumers owning cars that can be fuelled with more than one fuel. Considering that the choice of alternative fuelled vehicles, as well as the subsequent choice of fuel is complex, traditional consumer choice theory, which departs from rational behaviour, need to be complemented with theories that also account for uncertainties and risks, as well as normative behaviour and bounded rationality.

In this paper the aim is to synthesize earlier research about consumers' choices of AFVs and biofuels, where important factors that influence the two types of choices are discussed and research gaps are identified. The study departs from consumer choice theory and examines how previous literature relates to behavioural aspects of the choices of AFVs and biofuels. More specifically the review includes studies on the choice of vehicles that run on biofuels besides gasoline and diesel, and the choice of fuel in case having a vehicle that runs on more than one fuel. The two choices are examined and differences and similarities in how earlier studies of AFVs and biofuels have addressed factors that influence the consumer choices are scrutinized.

To the author's knowledge no reviews of previous literature on consumers' choice of biofuels exist, rather reviews of biofuels concentrate on fuel properties, combustion performance and environmental effects [2], [3]. Previous reviews about the choice of AFVs focus primarily on methodological aspects, explanatory factors of the choice and recommendations from previous studies for the penetration and modelling of demand on AFVs[4], [5]. This paper contributes to existing literature by filling the gap of reviews on consumer choices of biofuels, as well as increasing our understanding of the behavioural aspects that influence the consumer choices of AFVs and biofuels.

METHOD AND THERORETHICAL FRAMEWORK

A systematic database search was used to attain the papers included in this literature review, using relevant keywords in different combinations. In addition, while going through the earlier studies references to further literature was discovered. No time frame for included articles was used, nevertheless the development of new techniques and the inclusion of environmental and behaviour aspects when considering choice processes make recent studies seminal and of high interest. The focus here is earlier research studying consumer choices of AFVs and biofuels; therefore papers studying other choices of transportation, such as public transport alternatives and mobility as a service, as well as more technical studies, are excluded. Theoretically this paper departs from consumer choice theory, including behavioural aspects of consumer choice. A narrative literature review is combined with a theoretical analysis and discussion. By comparing and analysing the choice of alternative fuels and AFVs on the basis of behavioural economics, a discussion regarding how previous literature has addressed behavioural aspects of the choices can be made.

RESULTS

The results contribute to improved knowledge on consumers' choices of alternative fuels and AFVs, especially regarding important behavioural patterns and factors affecting their choices. An overview is given of which aspects that are included in previous papers on consumer behaviour. In order to make the choice of fuel, consumers need to have some sort of hybrid car that runs on several fuels. Choosing one fuel when filling the tank, consumers can still make another choice the next time they fuel, while choosing which car to purchase is more static and most consumers will stick with their choice for a longer time period. The choice of vehicle in general involves a larger investment and is a choice made seldom, while the fuel choice is a more frequent choice and less costly each time. This may imply several differences in how consumers relate to and the significance of costs, information, risk and uncertainty, social and personal norms, and other behavioural aspects in the choice situation. The results from this paper display how behavioural impacts have been considered in the various studies.

CONCLUSIONS

Information about how behavioural aspects of consumer choices can alter between different types of choices is vital for both policy makers and various stakeholders of the automotive and fuel industry. When considering different policy instruments needed in order to attain a transport sector with less emissions, it is important to understand what influences consumers' choices of AFVs and biofuels as this can give crucial insights for decision makers in the future promotion of fossil free fuels and AFVs.

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THE EFFECT OF MESSAGES ON THE INTENTION TO BUY ENVIRONMENTAL PRODUCTS: AN EXPERIMENTAL STUDY

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Keywords: Individual/social benefits, Pro-environmental products, Environmental communication, Marketing, cultural self

1. INTRODUCTION

The present study examines what kind of message is most effective at promoting the purchase of environmentally friendly products which are not currently accepted widely. Most environmental products promise two types of benefits: individual benefits and environmental protection. It is not confirmed which benefit should be emphasised to promote the purchase of new environmental products. Evans et al. (2012) examined the effect of messages on pro-environmental behaviour and found that participants performed higher pro-environmental behaviour when they received environmental information than the control group, while there was no difference detected when they received only financial information [1]. Sugiura (1998) discussed the importance of congruence between the sender of the message and the contents of the message [2]. In his study, a message to promote an ecological telephone system, which had both financial and ecological merits, was shown to participants. The message was most effective when the sender of the message and the contents were congruent.

This study also examines the mediating effect of the cultural self on the effect of pro-environmental messages. Markus & Kitayama (1991) suggested two types of cultural self; an independent self and interdependent self [3]. Those who are high in interdependent self were more likely to prioritise harmonious relationships with others. According to this theory, a message from a friend will have a stronger effect on those high in interdependent self.

To summarise, the purpose of this study was to examine the effects of messages on the promotion of environmentally friendly products by 2 (sender of the message: company, friend) x 3 (contents of the message: individual benefit, ecological benefit, mixed) design.

2. METHOD

A hypothetical experimental scenario was conducted with university students in Japan. A total of 151 participants (Female 108, Male 43) were given the following; a leaflet which contained a base message, a pre-questionnaire, a message from company or friend and a post-questionnaire. The base message contained basic information on a portable photovoltaic device. Following the pre-questionnaire, participants read a message from the company who produced the product, or a friend who used the product. The content of the message focussed either on individual benefits, environmental benefits or a combination of both. The difference in intention to buy the product in pre- and post-questionnaire was assessed as a dependent variable.

3. RESULTS

An ANOVA assessing the change in intention to buy the product as the dependent variable showed that the effects of the sender and the contents of the message were not significant. The next analysis examined the mediating effect of the cultural self. An ANOVA using the change in intention to buy the product as dependent variable with the sender of the message and independent self (high, low) as dependent variables demonstrated a significant interaction term ($F(1,147)=4.05$, $p<.05$). Those who are high in interdependent self expressed a greater intention to buy the product after reading a message from a friend.

We then conducted a multiple regression analysis to examine the determinants of a change in intention to buy the product. Independent variables were perceived behavioural control, subjective norms, individual/social benefits of the product and the evaluation of the sender of the message. The results showed that perceived behavioural control and individual benefits were significant determinants in both company and friend condition. The evaluation of the sender was significant only when the message was sent by a company, while subjective norms were significant only when the message was sent by a friend.

4. CONCLUSION

The result indicated that acceptance of the message sent by a friend has an impact upon the intention to buy the environmental product, depending on the level of the interdependent self. Those who are high in interdependent tend to try and meet the expectations of others; therefore, they were more likely to act on messages sent by friends. However, if a message was sent by the company, this effect was absent. The results also showed that the contents of the message did not have a significant impact on the change in intention to buy the product: number of participants per cell was not enough or the contents of the message was not strong enough. As practical implications, the results of the present study indicated that in East Asian countries where interdependent self is more dominant, those who want to promote environmental behaviours should send messages using interpersonal network.

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INTERDISCIPLINARY PEOPLE-CENTRED APPROACHES TO UNDERSTANDING AND IMPROVING ENERGY INFORMATION SYSTEMS IN PUBLIC BUILDINGS

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Keywords: people-centred approaches, anthropology, energy information systems, energy efficiency

1. INTRODUCTION

Buildings are held responsible for an approx. 40% share of the final energy consumption in the European Union. New technologies and IT solutions are being developed to automate indoor environments, as well as to allow detailed measurements and control over energy use and environment in buildings. Often left out of the equation are the building occupants. If smart technologies provide us with information on what is happening with systems and parameters in the building, they usually fail to explain why and how it is happening. The authors argue that in order for energy-related technologies to have the capacity of providing satisfactory and healthy indoor environments and optimise energy use, occupants of buildings should be involved in all stages of the development processes. They present an interdisciplinary people-centred research approach to energy-related behaviour and an energy information system through a case study conducted as part of an EU Erasmus+ co-funded project PEOPLE [1] in a building of the University of Ljubljana.

2. PEOPLE-CENTRED RESEARCH AND DEVELOPMENT APPROACH

The people-centred research and development approach is identified along two specific characteristics. First, it is an interdisciplinary approach, in which the social sciences are not in the subordinate role to the engineering in order to deal with the social factors, as is often the case in interdisciplinary undertakings [2]. Instead, qualitative research methods and anthropology-based insights lead the course of the research [3]. They are supported with sensor data mining. Second, the data on energy-related behaviour in the building enables the researchers to identify the ways in which technology could stimulate energy-efficient behaviour.

On the basis of the case study, the four (iterative or repeatable) steps of the people-centred development approach are presented: 1. identification, 2. analysis, 3. interpretation, and 4. testing. The essence of the approach is that users should be actively involved in all stages of the development process, from informing technological or non-technological solutions to increasing energy efficiency [4].

3. THE CASE OF THE SMART BUILDING AND ITS OCCUPANTS

The case study building is equipped with distributed architecture SCADA-based control system with 20.000+ I/O points. The study investigates how the energy information system, installed as a part of University of Ljubljana's energy strategy, could influence energy-related behaviour of the building occupants. *MePIS Energy Buildings* archives and processes data from the measuring system, automation and SCADA systems, data on energy consumption and weather, and provides energy reports, consumption and costs analyses. The sample sensor data consists of 111,380 sensor measurements from 14 offices belonging to one of the three types – laboratory, cabinet, administration. The researchers used data analytics and visualisations to uncover the behavioural patterns. For each of the individual rooms, the data analysis reveals the occupancy pattern, frequency and timing of opening the windows, indoor temperature fluctuation and manual adjustments, set temperature versus outdoor temperature, automated outdoor blinds patterns etc. For instance, administration and laboratories open windows regularly with a peak at around lunchtime. The researchers have substantiated these findings with qualitative data (participant observation and interviews) and questionnaire data analysis (N = 584).

4. CONCLUSION

The key element of people-centred research and development approach is the application of qualitative and quantitative research methods and data, in mutually enhancing modes, with the aim of integrating users of buildings in the entire development process of the energy-related technologies. The research findings show that the building occupants have a number of issues with the smart building, which have an impact on their health and well-being. High response rate and the number of received additional comments in the questionnaire (502) also reveal the occupants' frustration – regarding the air conditioning, temperature settings, lighting, lack of control over certain parts of the system, e.g. shades, as well as their sometimes insufficient knowledge of the possibilities for interacting with the system – and the necessity for conducting further people-centred qualitative studies on smart buildings and energy efficient behaviour. The results will be used to provide recommendations for improving the existing systems in the building in a way that will respond to the actual needs, as well as a tool to influence the occupants' behaviour to improve energy efficiency.

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UNDERSTANDING ENERGY EFFICIENT REFURBISHMENT DECISIONS: A PROCESS MODEL FROM THE HOUSE OWNER'S PERSPECTIVE

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Keywords: energy efficiency measures, private homes, decision process model, energy consumption modelling, barriers, intermediaries

1. INTRODUCTION

In order to reach climate protection goals, higher efforts must be directed at potential CO_2-emission savings. This especially applies to the building sector in Germany, where a reduction in the primary energy demand and CO_2-emissions can be reached by energy efficiency (EE) measures (e.g., thermal insulation or efficient/renewable heating technologies). However, the rate of actual EE-refurbishments in private houses in Germany stagnates at a very low level (ca. 1%, [1]). To understand the reluctant refurbishment behavior of house owners, social and environmental science research tried to identify barriers and promoters of EE-refurbishments [2] and modeled the decision process as strategic consumer decision [3]. At the same time, energy system models have been developed to model and predict the diffusion of EE-measures in the building sector [4]. These models mainly feature technical lifecycles and focus on house owners as rational, cost-optimizing investment decision makers. However, to reach a better understanding of house owners' behavior in EE-refurbishment decision processes and to improve the predictive power of energy system models, an integration of behavioural aspects is necessary. Moreover, consumer decision- and energy system models focus on the investor as single actor, thereby neglecting intermediaries as significant influence factor on EE-refurbishments decisions [5]. Therefore, we present an empirically based process model of EE-refurbishment decisions of private house owners, which includes relevant impact factors on the respective process stages and considers the impact of intermediaries as (so far disregarded) change agents in the EE-refurbishment decision process.

2. METHOD

To achieve a thorough understanding of the EE-refurbishment decision process, a qualitative research approach was applied. *Semi-structured qualitative interviews* were conducted with n = 10 private *house owners* as well as with n = 3 *amateur landlords*. A sample of n = 7 *intermediaries* (architects, craftsmen, energy advisor) was also interviewed to evaluate their impact on the EE-refurbishment process.

3. RESULTS

A process model with five subsequent stages of the EE-refurbishment process was derived, which encompassed the following stages: 1) perception of refurbishment needs, 2) information searching stage, 3) advice / planning stage of the EE-measure, 4) decision for a specific EE-measure, 5) implementation stage.

For stage 1, the *perception of refurbishment needs*, external triggers (e.g., technical defect, legal regulations, other renovation activities), and internal motivational factors (e.g., intended increase in property value, thermal comfort) were identified. For stage 2, the *information searching stage*, a first interface with intermediaries was identified since house owners start searching for information about EE-measures and about potential intermediaries. House owners are typically overwhelmed by the complexity of information about EE-measures and have difficulties in assessing the adequacy and effectiveness of EE-measures for their individual situation. In stage 3, the *advice / planning stage*, house owners get into contact with intermediaries, to get advice and select an intermediary to plan the EE-measure in more detail (for a more detailed analysis see [6]). Here, intermediaries play an essential role as knowledge facilitators for EE-measures as well as for the reduction of information complexity. Perceived promoters and barriers in the perception of the planning stage and the interaction with the intermediary were identified, which can lead to a continuation or termination of the refurbishment project. In stage 4, the actual *decision* for a specific EE-measure is being made. Here, intermediaries can play an important role, especially for investors with a low EE-measure knowledge level, since their recommendations strongly influence or even determine the decision for a specific EE-measure. Further criteria (personal preferences, availability of craftsmen, price) impacting the decision were identified. In stage 5, the *implementation stage,* the EE-measures are implemented. Investors' experiences during the construction work as well as energy savings lead to a final evaluation of the EE-refurbishment process, which is crucial for triggering further refurbishment activities in their own home or recommending EE-measures to others.

4. CONCLUSIONS

The EE-refurbishment process for private households is a complex, multi-level and -faceted process, which should not solely focus on the investor perspective, but also include the impact of intermediaries. From the moment an intermediary enters the process, it is a joint negotiation process in which both sides (investor and intermediary) bring in their ideas, interests, and knowledge. Interfaces of investor-intermediary-interactions were identified, which might serve as a lever for promoting EE measures. Our results can be used to develop more effective policy instruments to increase EE-refurbishment rates and to include house owners' decision-making behavior in a modelling tool for energy consumption of buildings. However, further research is necessary to detail and quantify the impact of intermediaries on the EE-refurbishment decision process.

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TRENDS IN BEHAVIOURAL ENERGY EFFICIENCY PROGRAMMES FROM 2010-2018 IN THE UNITED STATES AND CANADA

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Keywords: Energy efficiency, Behaviour, United States, Canada, Utility programmes

1. INTRODUCTION

The energy efficiency industry has increasingly recognized the potential of social science knowledge to expand the scope of programme possibilities and tap into new energy saving opportunities. To help programme administrators leverage these opportunities, the Consortium for Energy Efficiency (CEE) has collected information from its membership for each of the past eight years on the behaviour-based programmes currently underway and how they are evaluated. This is the largest annual energy efficiency behaviour programme data collection in the United States and Canada. This vast repository of programme information holds great promise for providing unique insight into the evolution of behaviour-based energy efficiency programmes over time and the new directions programmes have taken in recent years. We propose a presentation that would highlight the key findings of this research, the social science knowledge incorporated into the programmes captured, as well as the methods used and resulting limitations. This presentation would shed light on which behaviour-based strategies might be the most effective, evaluable, and promising in achieving quantifiable energy savings gains.

2. BACKGROUND ON THE CONSORTIUM FOR ENERGY EFFICIENCY

CEE is an award-winning consortium of 92 efficiency programme administrators from the United States and Canada. Members work to unify programme approaches across jurisdictions to increase the success of efficiency in markets. By joining forces at CEE, individual electric and gas efficiency programmes are able to partner not only with each other, but also with other industries, trade associations, and government agencies. Working together, administrators leverage the effect of their ratepayer funding, exchange information on successful practices and, by doing so, achieve greater energy efficiency for the public good, reaching approximately 142.9 million customers.

3. CEE BEHAVIOR PROGRAMME SUMMARY OVERVIEW

3.1. Purpose

Each year, CEE staff survey member energy efficiency programme administrators in the US and Canada. The purpose of this survey is to develop a programme summary that can serve as a resource for members and to help facilitate information exchange among the membership. It is intended to aid in the design and implementation of programmes with behaviour change elements by shedding light on what members consider to be behavioural programmes, how they're incorporating behavioural approaches into their programmes, and how they're measuring and evaluating these efforts. The resulting compilation of this data—referred to as the CEE Behavior Program Summary—includes information for over 100 programmes each year, and is the largest repository of US and Canadian behavioural programme information.

3.2. Methods and Related Caveats

The data compiled into the Behavior Program Summary each year is gathered through an extensive online survey. While no CEE member organization is obligated to provide a response, the survey is sent to all member organizations who participate in the CEE behaviour work area. Respondents are provided with a three-week window in which to complete the survey, and CEE staff follow up with non-respondents as time and other priorities allow. CEE receives data from programme administrators on a voluntary basis, and thus this data collection effort is neither a census nor a representative sample. As a result, the findings are unlikely to be generalizable to all US and Canadian behavioural energy efficiency programmes, yet they still provide a window into which types of programmes are being run in different jurisdictions, and the results of these efforts.

3.3. Data Collected

The CEE Behavior Program Summary collects myriad programme details, including the specific social science techniques incorporated into programmes (e.g. feedback, modelling behaviour, social norms, prompts, and goal setting), the sector (residential, commercial, or industrial) in which the programme is taking place, and whether any customer engagement technologies or platforms are utilized in the programme, among other programme components. The Behavior Programme Summary also sheds light on the evaluation details of the programme by including information such as the evaluation design, metrics used to measure success (e.g. energy savings, customer satisfaction, percent of target participants reached, or adoption level of efficient practices), energy savings achieved, and whether the programme administrator running the programme was able to claim the measured savings in their jurisdiction.

4. CONCLUSIONS

There are a few key takeaways from the past eight years of annual data on behavioural energy efficiency programmes in the US and Canada. First, behavioural approaches in the commercial and industrial sectors are more prominent than might be expected; while the majority of programmes reported to CEE took place in the residential sector, 26 percent were based in the commercial and another 12 percent in the industrial. Second, while energy efficiency programmes reported leveraging a variety of different social science techniques to help change behaviours in their programmes, some techniques have been used extensively whereas other have not yet been widely implemented. For instance, feedback, modelling, prompts, goal setting, and social norms are incorporated into programmes the most frequently. On the other hand, social science techniques such as reciprocity, public commitment, lotteries, and loss aversion, among others, have been less commonly incorporated into programmes in the US and Canada and represent ripe opportunities for wider deployment. Also noteworthy was the fact that just 42 percent of programmes reported using an experimental design for the evaluations of their programmes, which highlights the importance of continuing to develop rigorous yet practical evaluation approaches for behavioural energy efficiency programmes.

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EXPLORING FACTORS DRIVING SOCIAL COMPARISON IN ENERGY-RELATED ICT

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Keywords: ICT, Energy efficiency, Digitalization, Behaviour

1. INTRODUCTION

Decreasing household energy consumption is an important step in reducing global warming. While classical policy instruments (increasing prices and taxes) might have an undesired effect on low income households and stay unnoticed by the high income ones, new options enabling behavioural change, including among others nudging and social comparison, emerge [1],[2],[3],[4]. Modern technologies allow implementing social comparison as an easy-to-use and cost-efficient policy instrument to incentivise household energy efficiency and create a persistent behavioural change. Despite broad research of social comparison, several open questions remain. In particular, policy makers should understand who can be incentivized by social comparison and how to do it in the most cost-efficient and user-friendly way. Based on the data on 1500 Austrian households, using energy-related ICT developed in PEAKapp project, we aim to fill in this gap. We find that increasing the views of social comparison page within the app by one view per month decreases household energy consumption by three kWh per month holding other factors fixed. Further on, we investigate whether such factors as gender, dynamic pricing, dwelling ownership and size have a positive effect on the frequency of social comparison in energy-related mobile application.

2. PEAKAPP ICT-ECOSYTEM AND DATA

The PEAKapp project uses a specially developed mobile application to sensitize consumers to their energy consumption and motivate households to adopt and sustain behavioural changes through difference incentives including dynamic prices, social comparison and serious gaming. One of the main features of the app is the benchmark system, which enables users with similar households to compare their energy consumption. A special algorithm was developed using econometric methods to ensure the best possible comparability. Since social comparison is considered an important incentive to drive behaviroal changes optimizing households energy consumption, we investigate the specific factors that can be associated with a higher frequency of social-comparison through the benchmark system in PEAKapp. Within the frame of the PEAKapp, 1500 households were recruited to participate in the project. The households were randomly assigned to two treatment (with and without dynamic pricing) and one control group (with no access to the app). The data for this analysis is collected through Google Analytics service and households' smart meters from June 2017 to April 2018. A supplementary socio-demographic data, including information about household size and type, the type of heating, and the energy-relevant appliances present in the household was collected during a pre-survey and is included in the analyses.

3. RESULTS

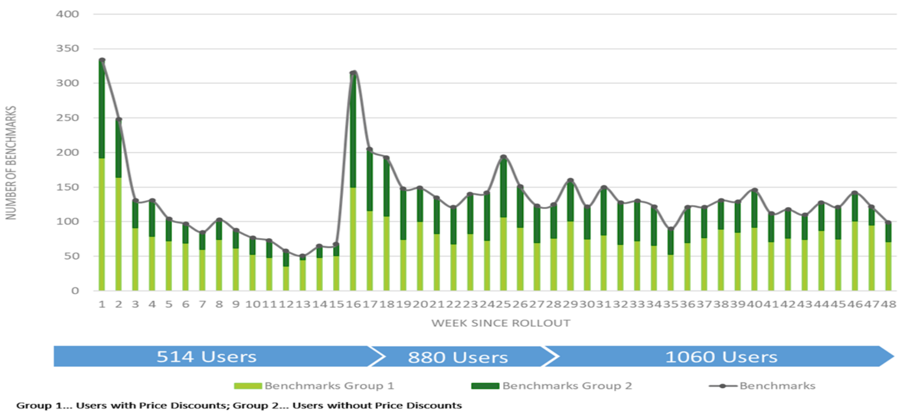

Figure 1. Benchmark page view per week.

The first graphical analysis of the data presented in Figure 1 shows the total number of benchmarks page views per week in the app by the users of treatment groups with dynamic prices and without since the first week of the project. Based on Figure 1, it can be seen that the groups differ significantly throughout the whole observation period: the app users of treatment group with dynamic prices visit the benchmark page more frequently. Next, based on several regression models, we examine the relations between household energy consumption and number of benchmark page views per month. Further, we investigate which characteristics of the household are associated with higher frequency of social comparison. We find that increasing benchmark page views by one per month decreases energy consumption by three kWh ceteris paribus. Also confirming the graphical analysis, we find that households with dynamic prices visit the benchmark page of the app more frequently than users without dynamic price. Furthermore, male users as well as users owning their dwelling and users with larger dwelling size tend to visit the benchmark page more often.

4. CONCLUSIONS

Increased penetration of mobile phones and tablets with mobile internet, allow to a fast and cost-effective provision of households with energy-related social comparison, which among other options can be an important instrument to decrease household energy consumption through behavioural change. The frequent usage of social comparison feature in energy-related mobile application can contribute to residential energy consumption optimization. Based on the data on 1500 households, we analysed the relations between energy consumption and social comparison as well as factors that are associated with a higher frequency of social comparison.

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ACTORS' BEHAVIOUR ANALYSIS IN A DECENTRALISED ENERGY SYSTEM: THE CASE OF THE GERMAN IRON AND STEEL INDUSTRY

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Keywords: decentralised energy, actor behaviour, disaggregation, energy modelling

1. INTRODUCTION

The German energy system is increasingly becoming diverse and decentralised through its spatial distribution of variable energy resources and its variety of actors, technologies and policies. As a result, ensuring that the ambitious goals of the Energy Transition are met in a cost effective manner has become increasingly complex. In order to address this issue, numerous energy system models have been developed to provide in-depth analysis of the potential future development of the German energy system. However, most models represent the diverse actors in an aggregated manner and thus fail to incorporate the heterogeneity of technical and behavioural characteristics of different players, which can consequently lead to achieving unrealistic results. The work presented here has a focus on the German iron and steel industry and is part of a larger assessment for the entire energy sector including power and heat supply, households, transport, the rest of the industry sector and other consumers. To incorporate heterogeneity of actors in German iron and steel industry we developed a methodological approach, which integrates the behavioural decision-making of actors with the technology-rich energy system model. The newly developed model with higher-resolution representation of actors is capable of capturing the diverse interests of different players towards investments in decentralised energy technologies or alternative process technologies in a cost efficient manner. Within this development, the paper aims at investigating the effects of those diverse interests on the development of the overall energy system and identify quantitatively cost-optimal measures for industrial GHG emission reductions for different actor groups in the iron and steel industry.

2. METHODOLOGY

The methods used in this study include the bottom-up characterization of actors in the iron and steel industry based on process technology and production capacity with the goal of defining groups of actors that better represent their decision-making behaviour regarding operation and investments in various technologies, especially decentralised technologies, under the respective framework conditions. The resulting actor groups are technologically enriched to appropriately represent their current status. Moreover, opportunities for investment on decentralised energy production are implemented, so that industrial actors' potential participation in the decentralisation of the energy system can be examined. To further improve the characterization of actors' behaviour, hurdle rates are introduced and assigned to actor groups and implemented in a scenario analysis (variable carbon tax prices) in a least-cost energy system optimization using the TIMES model generator.

3. CONCLUSIONS

Designing strategic policy instruments that steer the energy transition to a cost effective path is key to ensure that the ambitious national environmental targets will be met. However, which actors specifically should be targeted by such policy instruments, to what extent and how, still remains unclear. This work aims to address these questions by developing a methodology, which integrates the behavioural aspects of actors in technology-rich energy system model to gain insights on the roles of specific actors within the industrial branches. The results are expected to aid in capturing the diversity of actors regarding their decision-making behaviour towards investments and operation of decentralised technologies. This can reveal the potential contribution or impact of the actors that have been overlooked in the current energy system modelling practice and consequently help policy makers to better target those actors that can contribute to the desired energy transition in a more cost efficient manner.

RESIDENTIAL DEMAND RESPONSE IN THE LONG RUN: ASSEESSING THE EFFECTS OF A TIME-OF-USE POWER TARIFF 20 YEARS AFTER IMPLEMENTING IT

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Keywords: demand response, time-of-use, power tariff, spill-over effects, electricity use

1. INTRODUCTION

Boosting demand response is part of the answer to meet the call for a more efficient use of energy systems and resources. Despite the multitude and variety of the expected gains in increasing consumption flexibility, demand response programs are still exceptional in the Swedish power market. As part of their efforts to reduce overall diversified peak demand, a few distribution system operators have nevertheless implemented a time-of-use power tariff in all residential customer segments. There is plenty of empirical evidence that households respond to price signals by cutting demand in peak hours and shifting electricity use from peak to off-peak hours in the short term, e.g. [1], [2], [3] and [4]. There are, however, few studies on whether these effects prevail over time. Moreover, the questions remain whether the magnitude of demand response vary between, and on account of various demographics and other factors also within, different customer segments defined according to housing category.

Besides inciting consumers to behave in demand responsive ways, it is possible that a demand response program can also affect energy-related behaviours beyond those required for electricity use shifting. Evidence supports the notion that many pro-environmental or energy-saving behaviours are correlated among one another, e.g. [5] and [6], suggesting that possibly pro-environmental behaviours 'spill-over' to one another ([7], [8] and [9]). Yet within the literature on effects of demand response programs, few studies have attempted to test if consumers' shifting of electricity to off-peak hours is correlated to other energy-relevant or more general pro-environmental behaviours.

1.1. Objectives and methodological outline

Against the above background, an overall aim of the study is to assess the magnitude of demand response in the long term and to increase general knowledge on factors influencing residential demand response, including variables such as gender, age, income, educational level, occupation, heating system, household size and composition. Another aim is to investigate if demand responsiveness is related to performance of other energy-related pro-environmental behaviours.

The study is based on a questionnaire survey and one year of hourly electricity consumption data of some 3 000 households. Half the sample belongs to the treatment group, which has had the time-of-use power tariff for some 20 years, whereas the other half, which belongs to the control group, still has a conventional energy tariff. The households are furthermore equally distributed between the different housing categories single-family homes, condominium and rental apartments. The pen-and-paper survey consisted of 70+ questions and was distributed in the summer of 2017, with two reminders asking respondents to send back their answers. In total, 1133 valid responses were registered, distributed equally across tariff area (594) and control area (539).

2. RESULTS

Concerning the first aim, inspection of the consumption data suggests that the differences between the treatment group and control group are modest. Survey results give evidence in favour of assuming a difference between experiment and control group in terms of their self-reported past behaviour and future intentions towards shifting of electricity to off-peak hours, even when controlling for demographics like type of housing, age, gender, income and education. The effect is in the hypothesized direction, in that those in the experiment group report more load-shifting behaviours and intentions.

In relation, then, to the second aim, possible relationship between having a time-of-use tariff and other pro-environmental acts: for both experiment and control group, all pro-environmental behaviours (switching off apparatus from stand-by mode, travel by rail instead of air for domestic distances, consider energy-efficiency when purchasing white ware, eating more vegetarian food and recycling/sorting one's waste), correlated moderately with one another, including to self-reported shifting of electricity. When the two areas' mean intentions and self-reported pro-environmental behaviour are compared, intentions do not differ, but self-reported behaviour does, that is, the tariff-area reports slightly more pro-environmental behaviours. The effect disappears when controlling for age, gender education and type of housing, however.

2. CONCLUSIONS

In sum, preliminary results suggest that actual behaviour change in terms of load shifting is moderate, even after an extended period of 20 years. In terms of spill-over effects, and correlations to other pro-environmental behaviours, the evidence is ambiguous. On the one hand, self-reported electricity shifting was correlated to five other self-reported pro-environmental behaviours. On the other hand, between experiment and control group, that is, between those with and those without a time-of-use-tariff, there were no differences in pro-environmental behaviours.

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ENERGY EFFICIENT REFURBISHMENT WITHIN HOMEOWNER ASSOCIATIONS: A GUIDE FOR PROCEDURAL FAIRNESS

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Keywords: Energy efficient refurbishment, homeowner associations (HOA), process fairness

1. THEORETICAL BACKGROUND

According to the low-carbon economy roadmap set by the European Commission, greenhouse gas emission should be cut to 80% below 1990 levels by the year 2050 [1]. In order to reach this goal, different sectors need to contribute, among them the domain of housings and buildings. In line with this, the energy strategy of the federal government in Germany assumes a necessary increase of the energetic renovation rate of 2% per year. Currently, this goal seems out of reach, especially for homeowner associations (HOA). These represent 22% of the housing stock in Germany. Yet, the renovation rate among HOA is only at 0.6% [2], i.e. below the average of around 0.8% [3]. This leads to the question, what differentiates HOA from other types of buildings and may, thus, be the reason for the comparably lower renovation rate. One major difference is the complicated process to reach a decision among owners in HOA. According to the German condominium act, more than 50% of owners need to vote for necessary upkeep measures, 75% for non-necessary modernizations that have an advantage for owners (including many energetic renovation measures) and 100% for all other modernizations. Especially in larger, heterogeneous HOA, it is very hard to reach these levels of agreement for ecologically worthwhile renovations.

This situation is comparable to organizations undergoing major change processes that require the acceptance of all members in order to be effective. Planned changes often lead to opposition among members of an organization, even if these changes are necessary and reasonable [4]. A psychological reason for this is that change leads to experienced uncertainty, which goes along with subjective loss of control, causing feelings of insecurity, helplessness and fear. The same may be true for the decision processes in HOA concerning refurbishment measures, which may, thus, be a relevant barrier for refurbishments apart from other psychological (e.g. attitudes, knowledge) and non-psychological factors (e.g. financial, constructional or regulatory restrictions).

In order to minimize the negative effects of such a change process, it is necessary to plan a participatory process that is perceived as fair by all stakeholders [5]. Procedural fairness triggers many favorable attitudes and behaviors toward the person suggesting ecological renovations as well as toward the suggested measures itself. Therefore, making the decision process about an ecological refurbishment fairer should result in a higher motivation to participate and in more positive perceptions of the finally implemented measures. But what characterizes a fair process? Previous research has identified different aspects: neutral and trustworthy authorities and a respectful treatment during the process [6]. The single most influential aspect seems to be the opportunity to state ones' own opinion [7]. Voicing ones' own ideas and attitudes, regardless whether this leads to the desired outcome or not, makes people regard a process as fair.

2. CASE STUY

We tried to test this idea at the example of a medium sized HOA (35 inhabitants) in the area of Stuttgart, Germany. The property manager of the HOA was planning to exchange the heating system and asked the university to come up with different technical options and to design a participation process that allows for all owners to be integrated into the decision process. The project started in 2017 and the final decision of the renovation options should be reached by the end of 2018. In order to meet the requirements of a fair process, different communication and participation measures were implemented, preceding the actual decision.

- **Neutral and trustworthy authorities**: Members of a university were guiding the process as a neutral instance. All information presented was based on thorough research and all sources were presented openly to owners. In a survey with 16 owners of the HOA, 75% (strongly) agreed that the university is a credible source.
- **Respectful treatment**: The goal of the decision process was to empower owners in order to come to an informed decision regarding an energetic refurbishment. The planned process was outlined before and the owners were asked for commitment. All information during the process was made transparent via a “private“ web page especially designed for the HOA.
- **Giving owners a “voice“**: Following the approach of a 21st century town hall meeting owners were invited to events where different renovation options apt for their HOA were presented and discussed. As a follow up, owners were invited to online surveys that gave them the opportunity to state their individual view in an anonymous setting.

3. CONCLUSIONS

Even though the process has not yet led to a final decision and evaluation is still pending, the participation rate among owners was on a good level (more than 1/3 were present at the events and participated in online surveys), which may indicate positive reception of the process. On the downside, planning and moderation of the process is demanding and time consuming. Still, the remaining question is not whether a decision regarding energy efficient refurbishments should be based on a fair process, but rather, whether this will increase the likelihood for the refurbishment to be implemented in the end. Only then, it may be seen as a successful approach.

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ASSESSING THE IMPACTS OF HOUSEHOLD ARCHETYPES ON THE EFFECTIVENESS OF ENERGY RETROFIT

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Keywords: Household archetypes, Energy efficiency, Behaviour, Domestic retrofit

1. INTRODUCTION

This paper assesses the impacts of household archetypes (HA) on the effectiveness of domestic retrofits at the urban level. This is illustrated by a comparison between HA and Energy Performance Certificates (EPC) in terms of the energy saving potential derived from each. A given sample and case study dwelling were used in the analysis to exemplify the importance of incorporating HA method in developing retrofit strategies. Modelling tests were carried out using dynamic building simulation modelling to assess and compare the effectiveness of individual retrofit measures across these five household archetypes: active spenders, conscious occupiers, average users, conservers and inactive users. The overall energy and cost implications with regard to developing a retrofit strategy by incorporating HA are illustrated. The ambition is to enable a more realistic representation of retrofit saving potentials and to generalise the research outcomes nationwide.

2. METHODOLOGY

Initially, a base case derived from a mid-terraced house was selected to test the difference in the efficacy of optimal retrofit options guided by HA and EPC, respectively. The survey sample and percentage of each type of households was derived from a previous study [1]. The aggregated energy saving following various retrofits for each HA was compared with the retrofit saving using the EPC method that does not distinguish between household behaviours. After determining the estimated cost of each measure, the retrofit options were compared and ranked according to their energy saving per pound spent. Consequently, eight retrofit levels were formulated based on the number of retrofit options included. The first level had only one and the most cost-effective measure, while the eighth level included all the measures. This was based on the rationale that households would invest in more cost-effective measures first, however many they could afford. Here it was assumed that the cost and energy savings were the only factors in influencing households' choices of taking up retrofit measures. The Tariff Comparison Rate (TCR) was introduced to calculate the monetary saving potentials resulting from home energy demand reduction.

3. RESULTS

The results with respect to the cost-effectiveness of retrofit showed that the optimal ranking of measures varied for each household archetype. Despite the fact that the insulation of tanks and pipes came out on top, while window insulation ranked bottom across all household archetypes, all the other measures had somewhat different rankings depending on the archetype. For example, Smart Meters and Controls remained the second most cost-effective option for ‘active spenders’, ‘conscious occupiers’, and ‘average users’, but dropped to third and fifth for ‘conservers’ and ‘inactive users’, respectively. Similarly, a heating system upgrade was the second best choice for ‘conservers’ and ‘inactive users’, whereas it dropped to third, fourth and sixth for ‘average users’, ‘conscious occupiers’, and ‘active spenders’. All other measures related to building fabric insulation changed little in their rankings among different household types. For instance, ceiling insulation, wall insulation, and floor insulation remained third or fourth, fourth or fifth, sixth or seventh, respectively, among all users. Additionally, loft insulation ranked fifth for ‘active spenders’, but dropped to sixth or seventh for the other household types. In spite of the variation in their rankings, all the measures were much more cost-effective for households with a higher initial energy use, such as ‘active spenders’ and ‘conscious occupiers’. In other words, households composed of ‘active spenders’ would achieve a much higher return on retrofit investment compared with ‘inactive users’.

The HA method was demonstrated to have a significant impact on energy and cost savings from retrofit. At both dwelling and city levels, considerably more savings were achieved from using the HA method compared with that from EPC at most retrofit levels. In particular, the HA method could bring savings of over £5 million to £10 million per year at city scale with all but the first and third levels. While a smaller gap of about £0.7 million was found at the first retrofit level, a negative difference occurred at the third retrofit level suggesting more savings came from the EPC method when retrofitting with only the first three measures. Furthermore, on average a dwelling was able to make an extra £120 to £220 in annual savings at all retrofit levels except the first and third levels when guided by HA compared with EPC. The savings gap was especially prominent at the second and sixth to eighth retrofit levels. Overall, it was shown that using HA to guide the uptake of energy efficiency measures would significantly improve the retrofit saving potential.

4. CONCLUSIONS

This paper has illustrated the significance of incorporating household archetypes into any retrofit strategy. Compared with EPC, choosing retrofit measures tailored to each household archetype can considerably improve the energy saving potential, which may result in over £10 million cost saving annually at the urban level. On the dwelling level, an average household may save over £220 per year on top of the saving estimated from EPC. The modelling prediction has shown that the performance of energy efficiency measures may vary significantly and these variations can be distinguished by the use of household archetypes. With respect to cost-effectiveness, insulation of tanks and pipes triumphed across all archetypes, whereas window insulation ranked bottom. In spite of this commonality, the optimal ranking of the rest of the measures differs depending on the household archetype. By distinguishing between household groups, each household can work out the most favourable and affordable retrofit strategy. The prediction of the retrofit saving potential can also be improved in light of variations of behavioural patterns by incorporating household archetypes.

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IMPACTS OF THE FOSSIL FUEL DIVESTMENT MOVEMENT

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Keywords: Divestment, Fossil Fuels, Activism, Social Movements, Climate Change Governance

1. INTRODUCTION

The fossil fuel divestment movement (henceforth: Divestment) calls for institutions and organisations to remove their investments from fossil fuel companies. Divestment is an international network of local groups and activists, often student organisations. Within a few years, Divestment has spread to universities, local governments and other institutions and funds around the world, primarily in the global North. We consider the impact of this movement through literature review and interviews with activists, financial and institutional actors.

We draw on social movement theory to consider Divestment's current and potential impacts, acknowledging the difficulty in distinguishing the impacts of environmental movements from impacts of other actors and events [1]. We build on a framework defining three categories of social movement impacts [2]: *Political impact* could include influencing policy and power structures; getting demands on the political agenda; influencing public opinion; and gaining recognition of a group as legitimate representatives of an issue [2,3]. *Mobilisation impact* refers to organisational success and the ability to carry out collective action and affect the context for future mobilisations [2,4]. *Cultural impacts* can include creation of new identities and developing a collective consciousness among participants; and more widely, changes in social norms, behaviours, and institutional practices [2,5].

We further consider the distinction between *direct* or *material impacts*, e.g., impact of money divested on the fossil fuel and finance industries; and *indirect* or *contextual impacts*, which have long-term significance, through shaping socio-economic and institutional context and norms, even if their immediate effect is small [4,6]. Despite the large sums divested, the direct impacts of Divestment have for the most part been too small to seriously impact the fossil fuel industry. However, in common with previous research [6] we find that Divestment's indirect effects are far greater than its direct effects.

2. MAIN FINDINGS

One of the main impacts of Divestment is its contribution to the 'stranded assets' discourse, i.e., that fossil fuel assets are overvalued in the face of required climate change mitigation action. In recent years, fossil fuel companies have published documents countering arguments of their assets being potentially stranded, often following shareholder demand [7]. This defensive action suggests Divestment is already having cultural and political impact. Another impact is changing political discourse via the 'radical flank effect', allowing more moderate political discourse around climate change mitigation to gain ground [8], although activist interviews suggest this was not intentional.

A common argument against divestment is 'fiduciary duty' – the legal obligation of fund managers to seek best returns. This objection was undercut in December 2017, when the UK government announced it would introduce new investment regulations allowing pension schemes to mirror ethical concerns of their members, including addressing environmental problems. Divestment has clearly played a part in the public mood shift which allowed this change, another political impact.

A recurring theme in the interviews was that Divestment offered people, especially students and other young people, a platform with which they could engage in climate change action. Interviewees said Divestment offered *action*, something people could do beyond changing individual behaviour, both for student activists, swelling the climate movement's numbers, but also for mainstream, concerned investors. In the early 2010s, young people lacked a cohesive platform with which to engage climate change issues, and NGOs had trouble firing up the public about climate change; Divestment acted as a 'rallying call' for young activists, aligning with the reappearance of the student activism in the UK [9], and contributing to it through politicisation of students – demonstrating both cultural and mobilisation impacts. This matches other findings about environmental movements contributing to the vitality of democracy, not least through attracting young people for whom mainstream politics hold little interest, drawing them through promise of practical, demonstrable impacts [1].

Student activists were seen as naive by institutional and financial actors. Activist interviews and the literature suggest a mix: some believe the simplistic logic of direct impact from Divestment, but many others seeing it as a tool for reframing discourse, making fossil fuel an unethical investment (like arms trade and tobacco), forcing powerholders to address difficult issues, and remobilising students through collective action. In other words, seeking cultural, mobilisation and political impact.

3. CONCLUSIONS

- Divestment both benefited from, and contributed to, the rise of a new generation of student activism through offering a coherent platform for environmental action.
- Even Divestment's critics acknowledge its contribution to changing discourse around climate change mitigation, reducing the moral and political legitimacy of the fossil fuel industry.
- Divestment has successfully raised questions of how to engage with decision making on energy investments, contributing to changing behaviours among investors, shareholders and fund managers, and an overall cultural shift in the financial world.

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STRUCTURING DECISION SUPPORT FOR ENERGY PERFORMANCE ASSESSMENT OF SCHOOL BUILDINGS USING A SOFT SYSTEMS METHODOLOGY APPROACH

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Keywords: Energy efficiency; problem structuring methods; soft systems methodology; school buildings; value focused thinking

1. INTRODUCTION

Energy management in school buildings depends on several technological, social and organizational factors, resulting in a complex situation away from the usual engineering-focused approach. The main aim of the current work is structuring the fundamental objectives to develop a criteria tree at the core of a multi-criteria classification model to be used by management entities for rating the overall energy performance of school buildings. Improving energy management in schools has a strong potential for reducing the overall costs, also enhancing the conditions for improving educational quality.

The decision context is inherently unstructured, with multiple stakeholders with potentially conflicting perspectives and interests. According to the authors' experience the use of Problem Structuring Methods (PSM) offers an analytical framework for structuring the relevant evaluation aspects. These aspects are then included in a Multi-Criteria Decision Aid (MCDA) model aimed at classifying the energy performance of school buildings taking also into consideration non-energy effects. The option for using Soft Systems Methodology (SSM) [1] in this problem structuring process was due to authors' familiarity with systems language in face of their background on engineering and control systems. Within the context of decision aid processes, SSM has been used as a starting point to problem structuring for developing MCDA models [2], [3]. Similar approaches were followed in the context of sustainable urban energy planning [4], analysis of energy efficiency measures [5], energy behaviour modelling [6] and also within the European Union - funded project "Systems Thinking for Energy Efficient Planning (STEEP)" for developing energy master plans for districts in three European cities [7], [8].

2. METHODOLOGY

The first stage consisted of the identification of the main stakeholders as well as their roles and concerns in the process of improving energy efficiency of school buildings. The resulting *rich-picture* enabled to elicit information from stakeholders to refine it and hence the holistic view of the situation, which also contributed to understanding its social and cultural features. The use of SSM for problem structuring brought to discussion the main issues to be addressed during the assessment stage. The insights of the experts were useful to identify a set of fundamental objectives. Then, the set of objectives was structured in a criteria tree to perform the evaluation of the alternatives. The Value-Focused Thinking [9] approach revealed to be a suitable tool for structuring the decision makers' objectives and values to design the multi-criteria evaluation model.

3. CONCLUSIONS

The involvement of students, teachers and support staff was crucial to assess their own perspectives on energy performance and operational costs. These stakeholders are also key elements to help raising awareness and gain support from the local community in developing energy efficiency actions. This work bridges the human-centred and technical-centred perspectives regarding the assessment of energy efficiency in school buildings. The use of a PSM ("human-centred") approach to structure the decision criteria used in an MCDA model helped to better understand a complex situation and the role and importance of each stakeholder, as well as their relationships.

The ELECTRE TRI MCDA method, which is devoted to the sorting problem, was used to assess the energy efficiency performance of a set of school buildings. For this purpose, further interaction with decision makers was carried out to elicit the parameters conveying preference information required by this method. The final outcome was sorting the school buildings under appraisal into ordered categories of merit according to their performance in the multiple evaluation criteria. This information is relevant for grasping the results of a recent modernisation programme of school buildings as well as shaping policies for future interventions. The evaluation model can be easily adapted to other types of buildings, according to the decision maker's needs and preferences.

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Determining the similarities and differences towards energy-related behaviour between different types of formal social units: A set of parameters[i]

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Keywords: Formal social units, decision-making process, parameters, electric mobility, smart meters, buildings

1. EXTENDED ABSTRACT

This study presents an analysis of the parameters regarding the energy choices and energy related behaviour concerning the energy transition to low-carbon economy in the European Union and associate countries such as Norway and Turkey.

In order to systematically characterize the energy choices and energy related behaviour, the study focuses on the identification of the associated decision-making process. Hence, the components and dynamics of the decision-making processes are revealed, while also pinpointing the motivators and barriers that interact with the parameters and process components regarding the energy choices and energy related behaviour through qualitative analysis techniques.

Following a key concept of the ECHOES project framework which postulates that the ingredients and dynamics of the decision making process varies with respect to the level of the particular decision making unit, the analysis in this study is based on three levels of decision-making units within formal social units. This approach both establishes the parameters, including key factors and variables, and reveals the similarities and differences in between.

The three levels of formal social units considered are as follows: (1) Formal social units (policy-makers and/or energy providers), (2) Collective decision-making units (companies, local communities that are more formally structured, with relatively lower information and power asymmetries) and (3) Individual consumers engaging in joint contracts (individual consumers, typically characterised as having limited information and power, engaging in joint contracts to increase their power of

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negotiation). In addition, the analysis is structured around the three technological foci of the ECHOES project: (1) Smart energy technologies, (2) Electric mobility, and (3) Buildings.
The key factors, variables, and parameters regarding the energy choices and energy related behaviour are identified through qualitative inquiries: 15 Focus groups and 67 In-depth Interviews conducted in six countries, namely Austria, Bulgaria, Finland, Norway, Spain, and Turkey. The themes utilized in the design of focus group studies and in-depth interviews were obtained through a comprehensive literature review.
First stage of the analysis included open coding, which was used to break down, conceptualize and code the data. The second stage, utilized “axial coding” to categorize open codes for differences and similarities, as well as patterns and hierarchies. Finally, selective coding was applied, where the core themes of data are identified and the whole corpus is re-read to extract quotations that relate to and describe these emerging themes. Due to interpretivist nature of the research approach, triangulation was applied to ensure validity and trustworthiness of the findings (Shenton, 2004).
The findings demonstrated a set of factors that cause and mediate the decision-making process. At the level of formal social units, main parameters are top-level EU policies and directives, international agreements such as Kyoto and Paris, and national and local policies, which consequently use the former as their input. These documents not only form the basis for decision-making processes, but they also identify the framework, objectives, and possible approaches and methods for transitioning to low carbon economies. On the other hand, in collective units, for example in companies, certification requirements such as ISO standards, membership to organizations, the obligations arising from those memberships, future vision and respective strategic plans of the organization are significant factors that also have a decisive influence on identifying low carbon targets and how to take subsequent steps in collective decision-making processes. For individuals engaging in joint contracts, such as energy cooperatives or building management, the requirements arising from specific regulations or local directives are at the forefront. Particularly in the case of building renovations and integration of smart systems, these may play an important role in facilitating decision-making processes and may dictate the determination of methods.

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KEY SUCCESS FACTORS OF SUBSIDIZING ENERGY EFFICIENCY TECHNOLOGIES. FINDINGS FROM SWISS COMPETITIVE TENDERS

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Keywords: Energy efficiency promotion, electricity efficiency, tendering, subsidy rate, voluntary schemes, cost of avoided kWh

1. INTRODUCTION

Energy efficient technologies are often not economically viable for businesses. Payback periods of a decade or more are common for such investments. In order to trigger high market penetration of efficient technologies, policy makers sometimes employ subsidy schemes. In these programmes, public funds subsidize investments that are not yet economically viable. Thus, investors will be more likeable to purchase new technologies. A subsidy scheme should both reach an energy savings target, and save energy in a cost-effective manner. The literature on energy efficiency subsidy schemes usually focuses on measuring cost-effectiveness by determining costs for energy saved after controlling for windfall-profits (among others [1],[2]). This paper focuses on two important aspects that contribute to a programme's overall cost-effectiveness: the subsidy rate or percentage of investment covered by the subsidy, and overhead costs for the scheme's implementation. By analysing more than 100 of Switzerland's federally administered ProKilowatt subsidy initiatives [3], we provide evidence for how the design of subsidy rates and ~~the~~ management of programmes (resulting in overhead costs) are key to cost-effectively subsidizing energy efficiency.

2. THE SWISS PROKILOWATT POLICY INSTRUMENT

The paper analyses experiences of ProKilowatt, a Swiss policy instrument (www.prokilowatt.ch) that provides funding for electricity efficiency [3]. It is mandated by the Swiss Federal Office of Energy (SFOE). Since 2010, 389 projects and 140 programmes have qualified for SFOE support. They promote various measures for efficient electricity usage in lighting, electric motors, pumps, ventilation, compressed air, refrigeration, and others. An important feature of ProKilowatt is that it allocates resources through competitive tenders designed to fund electricity efficiency at the lowest possible price for government. Tendering is a useful mechanism for price-setting [4]. Various countries including Portugal and Switzerland promote energy efficiency this way ([5],[6],[7]).

3. DATA AND METHODOLOGICAL APPROACH

ProKilowatt uses two different approaches: projects and programmes. Projects cover bids from owners of installations subject to electricity efficiency measures. Measures with different end-consumers are eligible for programmes. This paper focuses on the experience of programmes~~,~~ as they vary not only in outcome~~,~~ but also in subsidy rates and overhead costs. ProKilowatt's efficiency programmes all commenced after 2010; each had between CHF 150'000 and CHF 3'000'000 at their disposal (about

EUR 130’000 to EUR 2’600’000). The programmes differ in terms of technology (type, complexity of measure), financing (subsidy rate, payback after subsidy), organisational structure (legal form of intermediary, existing customer/member base) and marketing approaches (funds and channels used for communication). First, we first analyse the impact of these factors on cost-effectiveness and goal-attainment. Then a number of case studies compare different programmes aimed at the same technologies but with varying degrees of success (water heat pumps, commercial refrigeration, circulating pumps).

4. FINDINGS

The evidence of electricity efficiency programmes in the Swiss policy instrument ProKilowatt underlines the importance of carefully evaluating and designing the two main cost components of subsidy programmes: subsidy rates and overhead costs.

The subsidy rate or percentage of the investment costs covered by the subsidy, can, in general, be set rather low and still allow for triggering investments in energy efficiency measures. A subsidy scheme can work well even if the after-subsidy payback is higher than normal thresholds for investment decisions. One explanation could be that the subsidised technologies offer multiple benefits; another is that subsidy programmes can trigger the attention of end-consumers and serve as quality labels for promoted technologies. In order to use public funds effectively, it is thus crucial to set low subsidy rates.

The role of organisational structure and marketing in implementing subsidy schemes is also important. It is necessary for an intermediary to have access to end-consumers of energy and to use informational measures. Proximity to the customer can be a factor in limiting both the subsidy rate and overhead costs. Policy designers of subsidy schemes could benefit from the involvement of business associations, regional governments, or similar entities.

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EMPOWER THE CONSUMER! ENERGY-RELATED FINANCIAL LITERACY AND ITS ROLE FOR THE DECISION-MAKING PROCESS IN HOUSEHOLDS

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Keywords: Energy literacy, financial literacy, energy related financial literacy, consumer awareness, energy knowledge

1. INTRODUCTION

Previous studies in energy economics have provided ample evidence of households underinvesting in new and more energy-efficient appliances, although this would be financially beneficial for them. In the literature, this is referred to as "energy efficiency gap". In the household sector this gap could be considerable in size given that several studies show a relatively large potential for residential energy efficiency improvements. Recent research in different countries suggest that only few people are aware of the savings they could realise by replacing their appliances by more energy efficient ones. Awareness about the possible savings requires both knowledge (e.g. about the energy consumption of appliances) and the ability to process this knowledge. So far, the literature has not developed a common concept of literacy in the context of energy-related decision making in the residential sector. An established stream of literature [1,2] has used a definition of "energy literacy", that focuses on the knowledge, attitudes and behaviour. However, recent empirical literature measures "energy literacy" as an individual's ability to calculate and compare lifetime costs of energy consuming durables [3,4]. Thus, the goals of this paper are the following: (1) introduce the concept of "energy-related financial literacy" that combines both the energy-relevant knowledge that households need to take informed decisions and also the set of skills that allow them to process this information, hence this concept captures the bounded rationality of individuals in a better way, (2) present empirical evidence of the level of energy-related financial literacy among a large sample of European households and (3) provide an econometric analysis of the determinants of the level of energy-related financial literacy.

2. METHODS

We analyse data from a large household survey (N=4500) completed in 2017 in three different countries in Europe (Italy, Netherlands, Switzerland).[i] The combined dataset includes information on household characteristics, dwelling characteristics and information on several aspects that are relevant to households' decision making with respect to energy use. Eight questions were included to elicit the energy-related financial literacy of the respondents: The first three questions asked about the electricity price, the operation cost of a desktop computer and a washing machine. The fourth question records whether respondents are aware about the savings potential of LED technology. The three standard financial literacy questions introduced by [5] are also included. Finally, respondents were asked to calculate and compare the lifetime cost of two different fridges. We compose an index of

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[i] The survey was conducted within the EU H2020 Project "PENNY" (Psychological social & financial barriers to energy efficiency), which applies a behavioural science approach to better understand individual behaviour in the domain of energy efficiency. The project runs from 2016-2019 and is funded by the European Commission, Horizon 2020 Programme. The data collection was implemented in cooperation with one large utility in Italy and the Netherlands. In Switzerland, the data collection was organized in cooperation with two utilities: one located in Winterthur (German part), the other located in Lugano (Italian part).

energy-related financial literacy, summing the scores obtained from each question. In a first step, we provide an extensive description of the level of households' energy-related financial literacy, as well as its heterogeneity across countries. Moreover, we estimate several ordered probit models with the aim of investigating the determinants of energy-related financial literacy. We then specify the energy-related financial literacy index as a non-linear function of several individual characteristics as: $Index_i = f(age_i, income_i, education_i, gender_i, country_i, employment_i)$.

3. RESULTS

In Table 1, we show preliminary results obtained estimating an ordered probit regression for the equation above. Age seems to be a significant determinant, showing that this index seems to be hump-shaped over an individual's lifetime. As well, income is significant and shows the expected signs. Gender and country of residence are also strong determinants.

Table 1: Ordered probit regression

Variable	Coef.	P>z
age	0.0289	0.006
age^2	-0.0003	0.002
Income: 1'501-4'500	0.1079	0.164
Income: 4'501-6'000	0.2614	0.004
Income: 6'001-9'000	0.2651	0.004
Income: 9'001-12'000	0.3629	0.001
Income: Above 12'000	0.2602	0.005
Primary school certificate	-0.7420	0.000
Lower secondary school certificate	-0.3486	0.000
Upper secondary school diploma	0.1009	0.100
5-year university degree	0.3002	0.000
Postgraduate qualification	0.4087	0.000
male	0.7561	0.000
IT	-0.4501	0.000
NL	0.0567	0.511
Other controls	YES	
Log likelihood	-5244.41	
N	2825	

4. CONCLUSIONS

The academic literature has not yet developed a common terminology of the term "energy literacy". In this paper, we summarize the existing literature on energy literacy and summarise what different authors understand under "energy literacy" and the related concept of "financial literacy". We introduce the concept of "energy-related financial literacy". This measure captures bounded rationality of individuals in the domain of energy-efficiency more precisely. We provide empirical evidence of the level of energy-related financial literacy among a large sample of European households. Finally, the econometric analysis using ordered probit models provides insights into the main determinants of energy-related financial literacy. Future research will focus on disentangling the role of gender from that of compositional differences (e.g. education) between males and females.

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CHANGING ENERGY-RELATED END USER BEHAVIOUR BY DYNAMIC, PERSONALIZED VISUALIZATION OF CONSUMPTION DATA

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Keywords: Visualization, Consumption data, Energy efficiency, Behaviour change, Interdisciplinary

1. INTRODUCTION

In the context of behavior and energy efficiency there has been an increasing focus on the potential of making consumption data accessible to end users through energy visualization systems. A meta-study has found that feedback can create energy savings around 10%, but also highlights that the method of feedback significantly impacts potential savings [1]. Other studies have analyzed existing energy visualization apps and have found that savings are affected by the design of the app [2],[3], the specific user group [4] and the social and cultural context [5]. Yet, despite numerous projects and studies the potential still appears to be untapped and there is a need for a coherent framework in order to develop efficient energy visualization. As practitioners in the field of energy efficiency and behavior change, we have developed a practice-oriented framework for designing and implementing an energy visualization app in households. Our approach is interdisciplinary and implies psychology, anthropology, digital development and engineering. By combining academically founded theories and methods with practical development and demonstration we have developed an extensive energy visualization concept and implementation strategy which is currently being tested in social housing estates in Denmark consisting of 620 apartments.

2. CHANGING ENERGY BEHAVIOUR

In our experience a recurring challenge for initiatives aiming at changing energy behavior is the widespread use of the *Information Deficit Model* [6] to explain behavior change. The model suggests a linear relationship between people's awareness of their energy consumption and the amount of energy used; With high awareness follows low consumption. Providing end users with raw consumption data should lead to a more energy efficient behavior. However, this linear conceptualization holds several assumptions that we find problematic: The notion that awareness alone causes behavior change, that humans are rational beings and that data does not acquire context.

2.1. The psychological antecedents of behaviour change

According to the theory of *Cognitive Dissonance* [7], new information does not always equal behavior change. Changing behavior is just one possible outcome, where reframing the situation or denying the information could be other ways to deal with the dissonance. Bearing this in mind, the way that information is presented to end users in a visualization app should always suggest behavior change that comes at a low personal cost [8], and emphasis must be placed on creating user motivation [9].

From other studies [4],[10], as well as our own research, we have found, that end users are motivated in several different ways to save water and energy. These findings have been distilled into nine so-called *initiating motivations* - reasons why people can be interested in their energy consumption prior to using a visualization app. The list includes saving money, caring for the environment, safety, an interest in monitoring data etc. We also work with 13 *retention strategies,* defined as ways to keep the users' interest in using the app continuously. The list includes elements such as novel content, progression, goal setting, curiosity, community and internal and external competition.

2.2. The process of anchoring technology

A core in the developed framework is combining technology with an extensive process of implementation. By using qualitative methods such as interviews and observations we create an iterative design process with end users to ensure that the visualization makes sense in the context of the user. In addition to this co-creation we outline a course of events, introducing end users to the purpose and use of energy visualization. The approach integrates the so-called *Action-Value Gap* [11] - the discrepancy between a person's values and the person's actual actions thus challenging the Information Deficit Model.

4. CONCLUDING REMARKS

On the basis of the framework, an energy visualization app called KeepFocus Cards has been designed as well as an implementation strategy. The app consists of a feed of *cards* that contain simple, visual information. The feed is rearranged continuously, as campaigns, energy consumption patterns and user input trigger the appearance of new cards. As of now the app is being used 620 social housing apartments. Quantitative as well as qualitative studies assessing the effect of the app are under way.

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FORMAL SOCIAL GROUPS AS PROMISING MIDDLE ACTORS FOR MUNICIPAL INTERVENTIONS: EMPIRICAL INSIGHTS FROM SIX STUDIES

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Keywords: Middle actors, formal social groups, interventions

1. FORMAL SOCIAL GROUPS: A PROMISING TYPE OF MIDDLE-ACTOR

A transition of the energy system is not a mere technical challenge but also requires major changes in individuals' and collectives' energy related decisions and behaviours. There is a large body of research on behavioral interventions aiming to curb energy consumption. What has shown to be conductive to behavioural change are measures promoted by peer-groups. One particular type of peer-groups that has so far received little attention in the energy field are formal social groups (FSG). These are locally active groups of individuals' whose members meet face-to-face on a regular basis. They pursue a certain collective purpose or goal and are characterized by personal ties. Examples of FSG comprise sports and leisure clubs; music groups (e.g. choirs); youth and senior citizen groups; neighborhood associations; political parties, charity and environmental groups.

These groups may promote individual behavioral change on a local level in many different ways. These include setting (injunctive or descriptive) norms, representing a trusted source of information and providing an arena for new experiences that may support the diffusion of more sustainable lifestyles. Given that many FSG comprise individuals with very heterogeneous backgrounds, they can also serve as a channel to individuals that cannot be reached by traditional campaigns and interventions. Furthermore, many local opinion leaders and decision makers (e.g. business owners, local parliamentarians) are members of one or even several FSG. With respect to promoting energy related behavioral change, FSGs are thus more than mere channels for interventions. Rather, they are middle actors [1] with a distinct agency and capacity to exert influence in all directions: downstream (their individual members), sideways (other FSG and local businesses) and upstream (local policy).

2. PROJECT BACKGROUND

Switzerland is a particularly well suited case to study as about 40% of the population is an active FSG member. Six different empirical studies were conducted as part of a project under the umbrella of Swiss National Research Program 71 *Managing Energy Consumption.* It analyses potentials of FSG to promote energy-related behavioural change[i]. The six studies are methodologically diverse and focus on different energy-related behaviors. Each addresses one or several facets of FSGs' role and potential to advance local energy transitions. One of them is **a systematic review** of organizations with a potential for supporting local energy policies, identifying almost 40 distinct actors with various degrees of agency and capacity [2][ii]. In order to better understand the general potential of FSG for downstream impact we conducted **two online surveys** [3, 4]. Eventually, **three field studies** were conducted, each focusing on a different pair of FSG and energy behaviour: local district associations/ e-bikes [5], sports clubs/ car usage, and swimming club/warm water saving [both forthcoming]. We will present the currently ongoing synthesis of these studies with respect to the potential of FSG to act as middle actors in energy transitions.

4. CONCLUSIONS

In summary, the studies suggest that FSG do indeed have a considerable potential in promoting energy related change of behaviour. This is because they enable reaching individuals that generally have a low affinity for energy and environmental issues but also because they keep group members committed due to group norms. Furthermore, we find that FSG can exert influence sideways and, in some cases, also upstream, mainly through the personal network of individual block leaders that are not only part of the FSG but also of other organizations (e.g. administration, SMEs or other FSGs). However, we also find that FSG are no panacea: aligning an energy-related measure or campaign with the goals and interest of a FSG often requires considerable resources as well as a certain flexibility in implementation. Hence, contextual knowledge on an actors' agency and capacity is crucial to determine whether the benefit of engaging a specific FSG outweighs its cost.

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[i] Project still ongoing (duration: fall 2014 to fall 2018), for details please see:
http://www.nfp71.ch/en/projects/module-4-acceptance/promoting-energy-efficient-behaviour

ii The key project output was an online-tool (url: www.energyactors.ch)

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PREDICTORS AND INTERVENTIONS REGARDING INVESTMENTS IN SUSTAINABLE ENERGY INNOVATIONS

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Keywords: Energy consumption; Sustainable investment decisions; Policy measures; Discrete choice experiments

1. INTRODUCTION

The current manner of households' energy consumption causes a number of severe global problems including global warming and depletion of fossil fuels [1]. Sustainable energy innovations are one important element to alleviate these problems. In Germany and other industrialized countries, some progress has been made in the field of electricity production in the last years (e.g., [2]). In other fields like mobility and heat consumption, however, the progress is much slower (e.g., [3,4]). In order to accelerate the energy transition, policy makers should foster the diffusion of sustainable energy innovations with effective policy measures. For that, it is most important to know how sustainable investment decisions are made.

2. THEORETICAL BACKGROUND

There is still a profound lack of empirical research on households' decision making in the context of sustainable energy innovations [5]. The available research suggests that external (e.g., technical, legal, social, or financial circumstances) and internal factors (e.g., the decision makers' motives, value orientations, or attitudes) play a role. Further research on the importance of the factors and their relevance for different decision domains is needed. The diffusion of innovations theory [6] describes the dynamics of innovation processes within society. It offers a suitable framework for assumptions about the adoption willingness of different kinds of decision makers in certain stages of the innovation process, depending on internal and external factors. When we apply the framework on the diffusion of sustainable energy innovations and decision makers in households, we can expect some factors to be more relevant for certain decision domains than for others. For example, technical interest should be most relevant as a motive for adopting innovations in the very early stages of diffusion processes (e.g., in Germany, adoption of electric cars). Social influences should be more relevant for adopting innovations that are more widespread (e.g., in Germany, installation of solar thermal energy or residential insulation; [7]).

3. METHOD

We conducted discrete choice experiments measuring investment decisions for or against sustainable energy innovations in German households. The decision domains were insulation measures, solar thermal energy systems, and electric cars. Our sample was experienced in making decisions in the respective domains. In the experiments, we varied several external factors referring to real world conditions (e.g., financial, technological, and legal aspects). We also included several internal factors (e.g., technical interest, eco-social value orientation, knowledge) and perceived social influences in a corresponding questionnaire.

4. RESULTS AND DISCUSSION

We found some of the factors to affect only certain decision domains. Notably, the influence of the decision makers' dispositions (e.g., value orientations, technical interest) varied between domains. Others factors affected all decision domains (e.g., financial aspects, social influences). Especially the large and stable effect of social influences under different external conditions was surprising regarding our differing assumption. The finding in its clarity is new in the context of households' investments in sustainable energy innovations. Studies investigating the role of social influences have so far been ambivalent about their influence on decision making, with a majority of studies indicating no direct effect [5].

5. CONCLUSIONS

Policy measures to foster sustainable energy innovations have often failed to be effective. Based on our findings, we suggest that policy makers should expand their set of intervention measures and address often overlooked leverage points. When using informational strategies, messages should be framed to target groups that show relevant dispositions for the decision domain. For example, when technical interest is an important disposition (as it is in the context of e-cars and solar thermal energy), messages should highlight the possibilities of user interaction. When eco-social value orientations are important for the adoption of an innovation (as it is in the context of insulation and, again, e-cars), a focus on environmental and societal benefits is suitable. Making use of social influences seems to be an especially promising approach. For example, efforts to foster network effects via normative messages, role models or block leaders could pay off on the path towards a sustainable energy transition.

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UNDERSTANDING HOMEOWNERS' RENOVATION DECISIONS RESULTING IN LOW CARBON RETROFIT

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Keywords: retrofit, decision-making, homeowners, energy efficiency, diffusion of innovations

1. INTRODUCTION

Encouraging low carbon retrofit among homeowners is widely recognised as an important strategy to reduce operational energy use in dwellings and mitigate climate change. A wide range of policies with varying levels of success has been implemented in the UK in an attempt to encourage low carbon retrofit among homeowners [1]. The formulation and logic of these governmental policies assumes a narrow, technical focus on operational energy use reduction, in which achieving carbon savings in the built environment are equated to the substitution of inefficient building services with more energy efficient ones and the insulation of the building envelope [2]. However, a review of the literature suggests that low carbon retrofit should be understood not just as a technical problem, but a socio-technical one, which accounts for a broader scope of social, economic, and sustainable dimensions [3]. There is also a lack of understanding of social aspects of a homeowner's decision-making process resulting in a low carbon retrofit. The current research aims to contribute to building such understanding.

2. THEORETICAL CONCEPTUALISATION AND METHODOLOGY

The home retrofit process can be conceptualized as an innovation adoption process, situated and shaped by the conditions of everyday life [2]. The theory of innovation diffusion explains how new ideas spread over time through communication channels in a particular social system [4]. Individual agents reduce inherent uncertainty associated with a new idea during the decision-making process related to its adoption. This process has five stages, during which an agent: (i) accumulates knowledge of a particular option, (ii) forms positive or negative attitude towards this option, (iii) takes a decision to adopt or reject the innovation, (iv) implements the new idea, and (v) confirms the decision. Different influences play a role at different stages of the process [2].

The research used a multiple case study design with a qualitative approach for data collection and analysis. Eight home retrofit cases were selected with a maximum variation purposeful sampling strategy. The aim was to maximise the sample diversity in terms of the retrofit timing. The 8 dwellings were selected from the SuperHome network. It is a UK-based voluntary network of homeowners that achieved more than 60% carbon reductions as a result of retrofit activities. Semi-structured interviews took place in owners' homes, retrofit processes were mapped together with the interviewees. Interviews were transcribed verbatim and decision-making processes were inferred from them. The analytical framework used matrices to look into different stages of retrofit decisions [3]. This framework provided the basis for cross-case comparison and analysis.

3. RESULTS, DISCUSSION AND CONCLUSIONS

The adoption of a sustainability-related retrofit measure or technology is difficult and inherently uncertain as to its outcomes. The uncertainty of the outcomes is associated with the trade-off between achieving the desired retrofit goals, and minimising the risk of unintended consequences associated with low carbon retrofit. The difficulty of retrofit implementation is associated with the level of the retrofit team's practical knowledge and the level of project management skills.

The homeowners have used several strategies to reduce the uncertainty of the retrofit outcomes. The strategies depended on homeowners' initial theoretical knowledge of low carbon retrofit. The owners were more confident to go for options they knew worked elsewhere. Otherwise, they got persuaded about various options through interpersonal communication with experts they trusted. Some owners, to secure the outcomes, adopted a number of retrofit measures that exceeded those necessary to achieve their goals. All owners were happy with the results of the retrofit.

In each case the owners were active member of the project teams and were involved at least in the management of the project. In the cases, where the owners had good level of initial practical knowledge or project management skills, the projects were completed without difficulties. In the cases, where the owners did not have sufficient project management skills and the teams did not have sufficient practical knowledge from the outset, it has been decided to learn by doing. If an initial project was of a big scale, it then grew out of scope, budget or required additional investment of personal time and resources. The owners in these cases found the retrofit experience exhausting and tiresome. However, in one of the cases, in which the owners did not have expert theoretical/practical knowledge or project management skills from the outset, a step-by-step retrofit approach was adopted, in which a result of every other installation showed them what else needed to be done. As each project was small in size and scope, they did not have negative experience of the projects going oversize and out of budget.

This abstract presents a part of the research findings with the following insights: 1) Homeowners' positive experience of both outcomes and the retrofit process appears to be important, in order to persuade others to retrofit their homes. 2) More effort should be put into creating social networks, through which homeowners could exchange their retrofit experiences and recommend products and construction experts. 3) A step-by-step retrofit approach may appeal to other owner-occupiers. These insights from retrofits in owner-occupied SuperHomes may help to develop policy that will support low-carbon retrofit in the private residential sector. However, research is needed into the advantages and disadvantages of step-by-step retrofit compared with the whole house approach.

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ENERGY INSTALLATIONS AS SOCIO-TECHNICAL SYSTEMS – BARRIERS TO EFFICIENT OPERATION FROM A SOCIAL SCIENTIST PERSPECTIVE

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Keywords: energy efficiency, interdisciplinary research, barriers to energy efficient operation, socio-technical system

1. Introduction

The European Commission has committed itself to reduce CO_2-emissions by at least 40 percent till 2030. Since around 40 percent of overall energy is spent for heating and cooling of buildings, within the last decade modern complex systems have been installed to provide energy in an efficient way. It is estimated that CO2-emissions can be reduced by 5 percent only by optimising energy efficiency [1]. However, there is evidence, that predicted saving potentials often could not be realised, indicating a need for optimization [2]. The interdisciplinary research project „ENGITO"[i] aims at identifying technical and organisational potentials for improved energy saving in the field of heating and cooling systems for non-residential buildings (e.g. schools, administration buildings and sports venues). Based on identification of potentials and barriers, low-investment optimization measures will be developed.

As theoretical background for the social-scientist analyses, we refer to approaches of social-technical systems. Socio-technical systems are described as hybrid constellations in which human, material and symbolic elements are closely linked and intertwined [3], [4]. Current research refers to the limitations of dominant economic and psychological approaches to understand issues of energy use and energy efficiency [5]. A socio-technical perspective allows to analyse interactions between the involved elements (as e.g. organisational aspects, competences of actors, political incentives as well as technologies and complex technical systems) and to gain an understanding of conflictual or so far neglected relations. Exemplary aspects are the controllability of complex technologies and assigning responsibility for energy efficient operation of the systems.

2. Methods

Analyses are based on on-site inspection of eleven non-residential buildings in Berlin and 33 guided qualitative interviews. The interviews were carried out with actors related to the heating and cooling systems as e.g. energy managers, building and system operators and users of the buildings. The interviews were recorded and transcribed completed. Content analysis was carried out with the software MAXQDA [6]. Additionally, in a workshop with nine building and energy system operators of six non-residential buildings possible optimisation measures were developed and discussed regarding their practicability.

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[i] The project ENGITO (Energy saving by low-investment technical and organisation measures for complex heating and cooling systems) is carried out at Technische Universität Berlin in cooperation between the Institute of Energy Systems Engineering (Fachgebiet Maschinen- und Energieanlagentechnik) and the Center for Technology and Society (Zentrum Technik und Gesellschaft, ZTG). It is funded from 2017 till 2020 in the Berlin Program for Sustainable Development (BENE) with financial support of the European Fond for Regional Development and the Federal State of Berlin (project number 1052-B5-O).

3. Results

Results show that - besides technical aspects - organisational structures, work organisation and actor related factors have a strong influence on operation of complex heating and cooling systems. In the analyses carried out so far, a frequently found barrier is the low priority of energy efficiency compared to other demands as e.g. smooth operation, comfort, and flexibility of users. Other important aspects are the lack of incentives and appreciation for energy saving. Additionally, conflicting interests of different actors play a decisive role: building operators want to avoid complaints, owners and tenants are interested in low energy costs and maintenance services aim at minimum effort which allows to gain higher profits. A lack of personal resources and especially of persons with adequate qualifications for management of the complex systems are a frequent problem. Responsibility for energy efficient operation of the systems is not always clearly assigned or the responsible persons are not able to carry out this task adequately due to high workload. Another interesting aspect is that high complexity of the systems makes it difficult to detect faults without specialised expertise which reduces possibilities of operators to intervene on their own.

4. Discussion and Conclusion

The approach of socio-technical systems allows to analyse processes of operating complex energy systems including actor-related factors and organisational structures. Barriers to operating the systems in an energy efficient way can be described as a result of the interaction between technical and social elements. With a socio-technical perspective it is possible to understand the organisational background of the observed symptoms better and base the development of optimisation measures on these insights. So far only public non-residential buildings were included in the analyses. Further analyses also of private buildings (companies) will show whether the results can be generalised. Current results indicate a high potential for optimisation regarding technical as well as organisational and actor-related aspects. Surveys in small and medium enterprises show that a lack of specialised staff who takes responsibility for this issue as well as information deficits are reasons why energy saving potentials cannot be reached. [7]. A lack of authority of the responsible energy managers for decision-making and issuing directives is another important aspect [8]. In Engito there are similar findings which will be dealt with in more detail in the future.

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HETEROGENEITY OF SOCIAL INFORMATION PROGRAMS: THE ROLE OF IDENTITY AND VALUES

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Keywords: Energy efficiency, Social information, Behaviour

1. INTRODUCTION

The influence of social information on behaviour has been demonstrated in a variety of settings. Research shows that telling people how their actions compare with those of similar others leads them to modify their energy and water consumption, their contributions to charitable causes, and their saving decisions. Despite growing interest in social comparison research, several open questions remain. In particular, relatively little is known about the sources of heterogeneity in the effect of a well-known experiment of social comparison, such as the one provided by the Opower program through the Home Electricity Report [1], [2],[3].

In our paper we speculate that environmental values represent an important source of heterogeneity in the effect of the Opower peer comparison. While the conservation behaviour of people with high biospheric values has been largely studied in the literature, little is known about the response of these individuals to peer comparison. In this paper we test the effect of social comparison on energy conservation and whether this depends on the extent to which individuals endorse high environmental values.

Another important gap in research is the understanding of the mechanisms behind individuals' reaction to the Opower Home Energy Report (HER) in the field of energy use. The HER delivers different elements, from a static neighbour comparison on energy consumption (descriptive norm), to feedbacks on how well an individual is performing (injunctive norm), as well as energy saving tips. A second objective of this paper is to test possible mechanisms that make the HER effective. First, we test if the HER shapes individuals' perceptions of the norm in the domain of energy conservation. A stronger perception of the norm in the direction of energy conservation may then influence energy consumption. Second, while environmental values tend to be stable in everyone's life, environmental self-identity can be influenced, for example, through information regarding energy conservation. A second mechanism could therefore be that the information delivered in the HER increases one's environmental self-identity. By activating biospheric values, the HER strengthens people's focus on benefiting the environment.

The analysis combines data from a large randomized program conducted by Opower in Italy, with survey data collected among utility customers. The data available from the utility details whether a person receives the social information through the Home Energy Report, the frequency and type of social information, customers' engagement with it and energy consumption. Survey data includes measures of environmental values, environmental self-identity, social norms and other household characteristics.

2. GENERAL SPECIFICATIONS

The first objective of the analysis is the impact evaluation of the HER program on energy consumption and digital engagement with the portal. The empirical analysis is conducted on a sample of customers of an Italian utility company (ENI gas and Luce), for the time period ranging from January 2015 to December 2017. The sample consists in 4'535 customers, of which 3,720 and 815 from the treatment and control group, respectively.

A second objective of the paper is to assess the heterogeneous effects of the program along two dimensions. We aim to test how treatment effects vary with respect to pre-treatment energy consumption as well as baseline environmental values. This analysis aims to answer the question on which customers' characteristics make them more likely to respond to the HER communication.

A third objective of the study is the question on the mechanisms behind the effect of the program. To shed light on the role of two possible mechanisms, we conduct manipulation checks. We first test if the communication received through the eHER affects environmental self-identity. We also test if HER influences a perception of the social norm related to energy conservation.

3. RESULTS

A very robust finding of the analysis is that pre-treatment usage along with environmental values are the major sources of heterogeneity. Families with higher pre-consumption respond to the intervention by curbing energy consumption. Conditional on high pre-consumption, people who strongly endorse environmental values, are more likely to respond to the social information by cutting energy consumption. Second, the HER increases environmental self-identity among people with high pre-consumption. Another important result is that the HER increases the perception of the social norm in favour of energy conservation. Interestingly, this effect holds for both high-consumption and low-consumption households.

4. CONCLUSIONS

Taking all these results together, one can infer that high pre-consumption households are induced to reduce home energy consumption by the HER because the HER increases their environmental self-identity. On the contrary, the HER influences the social norm among low pre-consumption households but this effect does not translate in lower energy consumption among this type of families. One can therefore argue that the social norm mechanism is less effective in conducting a final outcome in terms of energy conservation.

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PUBLIC DEBATE ON CARBON CAPTURE AND STORAGE: STATEMENTS AND VISUAL FRAMES USED IN DUTCH NEWSPAPERS

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Keywords: Carbon capture and storage; Media analysis; Public perceptions; Visual framing

1. INTRODUCTION

Carbon capture and storage (CCS) generally refers to the process whereby CO_2 emissions from industrial sources (e.g. power plants, oil refineries) are captured and stored in stable onshore or offshore underground geological reservoirs [1]. It has been acknowledged as a technology with the potential to reduce CO_2 emissions and has received growing interest from policy makers [2]. Public perceptions and acceptance are important factors influencing the successful implementation of CCS [3]. Media reporting of CCS provides insight into the emerging relationships between the public and this technology [4]; moreover, public debate is influenced by how information is framed in the media [5,6]. Responding to a lack of studies on media representations of CCS [7], this paper examines the statements used in favour and against CCS in Dutch newspapers. Media representations of CCS will be compared to previous Dutch media analyses in 1991-2006 [8] and 2009-2010 [9]. Furthermore, the images printed alongside CCS articles are analysed to explore how CCS is visually represented in the media.

2. METHOD

Newspaper articles for this analysis were retrieved from the LexisNexis® Academic database using the keywords CO2, carbon dioxide, CCS, capture and storage. Articles were gathered from eleven leading national daily newspapers and one relevant specialist newspaper, over a 6-month time period (August 2017-January 2018). This period includes the announcement by the Dutch government on 10 October 2017 to commit to developing CCS as part of its effort to cut CO_2 emissions. A total of 213 articles were retrieved, irrelevant articles (according to set criteria) were removed and the remaining set comprised of 66 articles. A quantitative content analysis was done to explore article characteristics, such as the overall evaluation of CCS (i.e. positive if the majority of statements were in favour of CCS; negative if the majority of statements were negative towards CCS; balanced if the article contained both positive and negative statements; and neutral if the article made no judgment about CCS). Qualitative analysis was used to identify emerging themes from the statements, and a visual content analysis was done on the images attached to newspaper articles on CCS.

3. RESULTS

The majority of coverage on CCS was in October (N = 41), with only four articles published in August and September, and twenty-one articles in the period from November until January. CCS was the primary topic in 46% of the articles, and 76% focused on CO_2 capture from industry sources. Overall, coverage on CCS tended to be mixed; with slightly more negative (36%) or neutral (24%), compared to positive (20%) or balanced (20%) articles. These percentages were similar for newspapers in the left-and right-leaning political spectrum. Negative statements towards CCS mostly focused on infrastructure, economy and sustainability. CCS was described as a technology with limited experience, and there was a worry that financial investments would come at the expense of renewable energy development. Within the positive statements very similar overarching themes emerged, with the main focus being on sustainability. There was an overall sense that CCS would be inevitable in able to reduce carbon emissions. Infrastructure and economy arguments were also common, describing CCS as a 'proven' technology that has financial benefits. Twenty articles were accompanied by one or more images, CCS was visually represented as a political (images of politicians/stakeholders; 45%), industrial (images of industry/smokestacks; 30%) and complex (graphics; 25%) issue.

4. CONCLUSIONS

An interesting question is how the current results relate to previous media analyses. The discussion around CCS in the Dutch media seems slightly more negative compared to 10-15 years ago when the technology was presented in a somewhat more positive and balanced way [8]. The statements used have remained similar but CCS is now more commonly framed as a sustainability issue compared to an economic issue [9], and safety/risk concerns [8] appear to be less at the forefront of the discussion. Also, new technological developments and changes in policy (e.g. closure of fossil fuel power-plants) have meant a change in discussions towards opportunities for industry and also the possibilities of utilising captured CO_2. The effect that the current slightly more negative reporting and visual framing of CCS as a political, industrial and complex issue will have on societal acceptance of newly planned CCS developments in the Netherlands is unclear. However, given that for the general public CCS is still a relatively unknown technology the media will likely play an important role in influencing public debate on CCS.

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USER-CENTRIC MEASURES OF PERCEIVED LIGHT QUALITY: DEVELOPMENT OF TOOLS TO PROMOTE ENERGY EFFICIENT LIGHTING

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Keywords: Light quality, experience, communication, energy efficient lighting

1. INTRODUCTION

Electricity for lighting constitutes a large share of the total energy use in buildings, about 20 % for households and 40 % for commercial buildings. At the same time, Europe is facing a shift towards more energy efficient lighting. The potential for energy savings is thus high, for office spaces at least 50 % [1]. Nevertheless, customers tend to prefer incandescent fixtures (light bulbs) as they are experienced to provide good comfort. To motivate building owners and users to convert to more energy efficient lighting, it is therefore necessary to prove not only financial advantages and energy savings, but also positive experiences and increased light comfort. However, knowledge, concepts and tools for communicating and measuring visual light quality are lacking.

Whereas light in the sense of radiation can be measured physically, the experience created when light hits the eye is far more complex. The process cannot be translated into physical terms, and yet it would be needed to ensure good light environments. The only established tools to measure light quality are the Lighting Standards, such as the European standard (EN 12464-1). It is based on photometry, which is in turn based on physical units and only measures a very limited part of the light experience. The lighting standards are thus insufficient as tools for creating good light environments and may even result in oversized lighting systems that affect both well-being and energy use negatively.

The aim of the research presented is to support the implementation of light environments that cater both energy efficiency and well-being by providing tools that support communication about perceived light quality between professionals in lighting design and procurement.

2. RESEARCH METHODOLOGY

Three parallel processes feed in to the development of a communication tool on light quality:

i. Parameters describing objective experiences of lighting products (*sensory analysis*).
ii. Parameters describing subjective experiences of light environments (*visual perception*).
iii. Experiences and practices from the *lighting industry* and professional customers.

Sensory analysis measures and interprets reactions on products and services as they are perceived by our senses. The scientific discipline was defined by Sidel and Stone in 1974 [2]. The analysis includes both qualitative and quantitative approaches, and measurements include both subjective consumer tests and objective measurements by trained panels. Since 2014, sensory methodology has been developed for lighting products [3]. Analytical (objective) assessments have been carried out in a multisensory laboratory at RISE Research Institutes of Sweden at several occasions. A panel fulfilling specific criteria has been trained to assess light sources and fixtures.

To assess and describe the *visual experience* of light quality, concepts (descriptive words) are collected from different sources and are validated through user studies [5]. To create a concept model for visual experience of light, a typology for light environments has been developed within this project. It is used to systematically collect and validate concepts in workshops and test studies [6]. The emotional experience is also investigated, using semantic methods from environmental psychology and Kansei engineering [4]. In Kansei engineering, users' emotional preferences to product characteristics are quantified and represented by mathematical models.

Support from professionals is a prerequisite for implementing an extended definition of light quality. More than 30 representatives from the Swedish *lighting industry* and real estate industry have therefore been engaged in the research project. By taking part in a workshop series, they actively and iteratively contribute to the development and design of the communication tool. The purpose of the workshops is threefold; 1) practitioners provide input and feedback to methods and tools, 2) engagement as part of achieving acceptance and approval for the project outcome, and 3) provide an arena to intensify the discussion about perceived light quality among professionals.

3. COMMUNICATION TOOL

Tools aiming to support communication about light quality between professionals in lighting design and procurement are under development. The first phase of the development focused on collecting parameters, concepts and definitions describing perceived light quality, while the second phase includes structuring and visualizing the parameters to support communication. One possibility would be a tool similar to the aroma wheel for wine [7].

4. CONCLUSIONS

The research project is ongoing and the intermediate conclusions include:

- Assessments and physical measurements produce complementary information about lighting.
- A first draft of domain for visual and emotional experience of light, connecting concepts to specific characteristics of experienced lighting qualities, has been developed.
- Lighting professionals show considerable engagement in extending the definition of light quality to support light environments that cater both energy efficiency and well-being.

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METHOD FOR MEASURING OCCUPANT BEHAVIORS AFFECTING INDOOR AIR QUALITY IN APARTMENTS

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Keywords: Occupant behaviour, Energy efficiency, Airing, Indoor air quality

1. INTRODUCTION

Healthy indoor environments in dwellings require good air quality with low levels of adverse gases and particles. Air exchange between the dwelling and the surrounding environment is needed, i.e. ventilation or airing. In newer buildings in Sweden, mechanical ventilation with heat exchangers are standard, with the objective to provide an adequate air exchange rate and dispersion. However, despite well-adjusted ventilation systems, occupants perform airing by manually opening windows, doors and vents. This is a problem of significance in cold climate countries, as it increases energy use for heating. There is a need to better understand occupants' airing habits and motives for airing, both with regard to indoor air quality and other comfort factors such as temperature, and individual factors such as needs, preferences and understanding. Airing habits have traditionally been assessed with observational and self-reporting methods. These methods are useful, but have drawbacks. Observations can only be carried out within a limited time period and self-reported methods rely on the reliability of the respondent. It has now become easy and affordable to also use technical measurements to record actual airing habits. We have developed a method that reliably detects and records actual airing habits, using commercially available consumer products, through hall-effect sensors mounted on doors, windows and airing vents in homes. The method was tested in the PEIRE (People-Environment-Indoor-Renovation-Energy) project, which studies indoor environment quality in multi-family housing, with a holistic perspective, before and after a major renovation that includes energy efficiency measures.

2. METHOD

The behaviour measurement system (BMS) is composed of off-the-shelf home automation equipment and various sensors. Data from the system is logged locally within an embedded computer at the participant's home. The system also connects to the Internet, allowing for remote monitoring of status of the system and identification of potential problems and discrepancies during the measurement period. The BMS consists of a Raspberry-Pi computer, a 433 Mhz controller and a 3G mobile internet modem, magnetic sensors, temperature and relative-humidity sensors and motion detectors that send data wirelessly to the controller. In this study, magnetic sensors were installed on all opening windows, doors and ventilation hatches in ten participants' dwellings to detect airing behaviour. Motion, temperature and relative-humidity sensors were installed in the kitchen hood to detect cooking activity. Other motion sensors detected presence in the dwelling, along with temperature and relative-humidity sensors which detected changes in the indoor environment. When assessing indoor air quality, the measurement of airborne particulate matter concentrations is important. Particle number concentration, mean particle diameters in the size range of 10-300 nm (NanoTracer, Oxility Aerasense) and particle mass concentration, PM2.5 (DustTrak Aerosol Monitor, Model 8520 TSI; Micro-Aethalometer, AE51) was measured inside and outside. Sampling was done during seven consecutive days. During the period of measurements, residents were asked to keep track of their daily indoor activities (e.g., cooking, candle burning, housekeeping, window opening) and periods of presence/absence at home in activity logbooks. The occupants were also asked about their general habits in a questionnaire. Interviews with the objective to explore the occupants' needs, preferences and understanding supplemented quantitative data. Data from the BMS were correlated with the resident's activities and behaviours such as presence and cooking based on the logbook notes and with air quality measurements.

3. RESULTS

Results from measurements made in the PEIRE-project before renovation showed that it was possible to map occupancy behaviour in the dwellings by the BMS and applying algorithms to data analysis. There was a high conformity between technically measured behaviour and measurements of the indoor environment such as temperature and particle concentrations (e.g., clear increases in particle number concentrations during cooking activities or candle burning, and decreases due to window opening.) The results encourage further analyses with the aim to capture cause-effect relationships. The various technical measurements also corresponded fairly well with self-reported accounts of behaviours such as cooking activities. Differences between technical and self-reported measurements were though in some cases large, mainly due to inadequately completed diaries or questionnaires

4. DISCUSSION

We were able to achieve reliable, quantitative data on occupants' behaviour, over a period of time, to a relatively low cost. The measurements gave new insights on airing habits and other activities, and could easily be tested against simultaneously measured indoor air quality and temperature. The data, together with diaries and questionnaires, provide a base for studies of complex systems such as indoor environments in dwellings. However, in order to interpret and enable effective use of this quantitative data, qualitative data are also needed. Occupants' perceptions of the indoor environment and motives for behaviour are examples of factors that should be included in a holistic study, and that are best obtained by the occupants' own stories as told in for example interviews.

5. CONCLUSIONS

For measurements of behaviour in studies of complex systems, a combination of technically measured and self-reported behaviour provide good data for analyses with a holistic approach. Increased understanding of the interaction between humans and the indoor environment provide basis for user based interfaces for increased comfort without unnecessary energy use.

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Mapping structure for interviews on energy-related behaviour and underlying motives of residents in large, underused Flemish dwellings

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Keywords: Energy sufficiency, User-environment interaction, Analysis method, visual mapping,

1. PROBLEM AND OBJECTIVE

Due to socio-economic developments (e.g. smaller household sizes) and a large average living space, 40% of (semi)-detached single-family dwellings in Flanders are underused. Nevertheless, the energy policy induces energy improvement of the whole building volume, regardless of size and user practices. This allows a higher actual energy demand than needed for changing housing needs. In addition, optimization of the entire building skin leads to an increase in material consumption and renovation costs. Therefore, this study presents the development of an analysis method to gain insights in current energy-related user practices within this type of dwellings, with a specific focus on the seasonal variations in behaviour and experiences of comfort. These insights will be used to develop alternative renovation concepts based on dynamic living, energy sufficiency and resource efficiency.

2. METHODOLOGY

An in-depth case study is conducted within three large, underused single-family dwellings to explore the user-environment interaction as a determinant of the actual household energy demand. The interaction is defined by the resident acting on the environment and vice versa. Therefore, one interview was carried out with each household at the start of the research on energy-related occupant behaviour (occupancy and use of spaces), followed by 4 seasonal interviews with each of the household members on environmental experiences (users' comfort within spaces). The interviews are coded with NVivo to determine the properties of an active, dynamic resident and a varying living environment as influential factors on the energy demand. Secondly, the interrelations between these derived properties are mapped by means of a visual tool (Vectorworks) to unravel the complex user-environment interaction and its seasonal variations in an energy-related context.

3. RESULTS

Firstly, the coding of interviews on energy-related behaviour results in an overview of the different properties describing the users' interactions with the HVAC-systems and alternative actions limiting the need for heating (such as cooking or use of sweater or blanket) and occupancy of spaces (frequency, duration and rate). In addition, underlying motivations for these actions (comfort, activities and cognitive factors) and environmental determinants (spaces and climate) are derived. Secondly, from the seasonal interviews on environmental experiences, properties are derived on the

residents' comfort-level (positive, negative, neutral, contradictory), the type of comfort (psychological, functional and physical) and subjective comfort (perceptions, priorities and preferences). In addition, the properties of the physical environment (spatial, built and natural) that cultivate or mediate experiences of comfort are further defined.
The resulting coding schemes, containing all factors and their properties on occupancy, use and experience within spaces, serve as input for the development of a mapping structure. The mapping structure is developed in Vectorworks and aims to visualise in a uniform manner case-specific data (responses of interviews) on energy-related behaviour and environmental experiences throughout the seasons within these dwellings (Fig. 1).

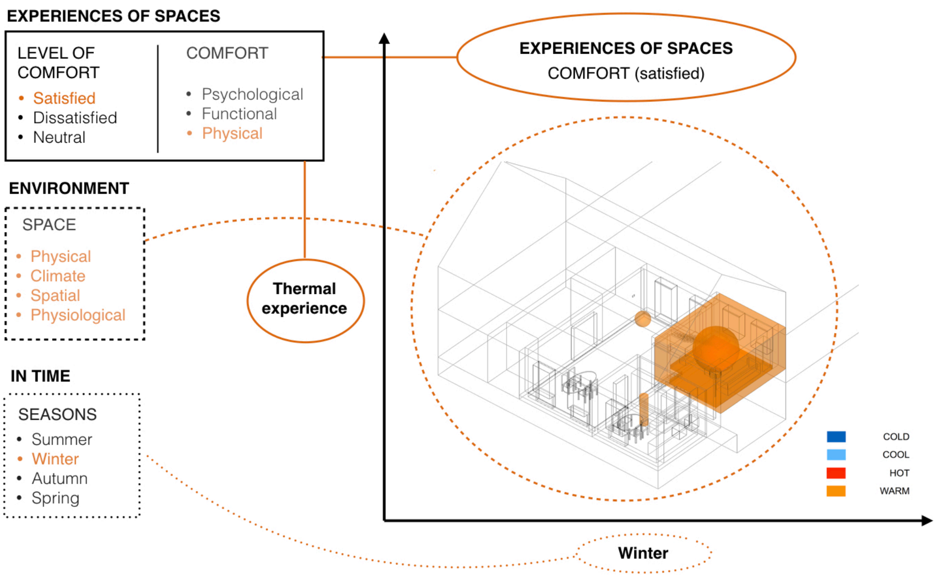

Figure 1 Example of structure for mapping responses on thermal comfort within spaces (visualisation of responses of one specific resident)

Analysis of the resulting maps on use and occupancy of spaces leads to insights on what, where and when energy is demanded, detailed up to the level of places within spaces and periods within the seasons. Secondly, maps on the experiences of comfort provide insights on why energy is demanded and when and where comfort is needed. Lastly, by relating user practices and comfort experiences to individual environmental features (e.g. windowsé, connection between spaces), insights are derived on how comfort is influenced by the designed environment and how energy is supplied. Therefore, the analysis of the in-depth case study, by means of the developed mapping structure, supports defining what energy *demand* is *sufficient* and how this energy can be *supplied* more *efficiently* within these large, underused single-family Flemish dwellings.

ONE FOR ALL? – THE IMPACT OF DIFFERENT TYPES OF ENERGY FEEDBACK AND GOAL SETTING ON INDIVIDUALS' MOTIVATION TO CONSERVE ENERGY

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Keywords: Energy conservation behaviour, Energy feedback, Goal setting, Motivation, Personal value orientation, Goal framing

1. INTRODUCTION

We investigate how different types of feedback, combined with goal setting, impact on consumers' motivation to conserve energy. While a lot of research has been devoted to energy feedback [1-4] and goal setting [5-8], little research has looked into the interplay between goal setting, energy feedback and personal values of energy consumers. We test the influence of energy feedback in physical units (kWh), monetary values (EUR) and environmental values (avoided CO2 emissions from car use) on the motivation to save energy of 631 Dutch households in an online survey. We combine the different types of feedback with a treatment in which some of the households are asked to set themselves a high, low or no energy conservation goal. In addition, we assess the respondents' value types as distinguished in Steg et al. [9] - hedonic, egoistic, altruistic and biospheric – to test predictions derived from goal framing theory [10].

2. METHODS

The motivation to reduce energy consumption was assessed with an online survey among 631 customers of a Dutch energy provider. Participants answered questions regarding their motivation to conserve energy in response to three different types of feedback, i.e. savings expressed in either kWh, EUR or environmental values (randomized order). In addition, respondents were randomly assigned to one of two treatment groups or a control group. Individuals in the two treatment groups were asked whether they would be willing to set themselves either a high (10%) or a low (2%) conservation goal. Finally, the respondents completed an adjusted version of the Schwartz value scale [10] and indicated their preferred type of energy feedback. The data is analysed with a series of logit models and a recursive bivariate probit model.

3. RESULTS

On average, we do not find a difference in the effectiveness of the feedback types. Asking respondents whether they would be willing to set themselves a conservation goal turned out effective only when asking to set a high rather than a low goal and only when exposing them to monetary feedback. If an individual actively agreed to set a conservation goal, this impacted the willingness to reduce energy consumption positively in the monetary and kWh feedback conditions, but negatively in the environmental feedback condition. Regarding the value types, we found that altruistic values positively predicted energy conservation in the kWh and monetary feedback conditions. Biospheric values predicted goal acceptance and energy conservation behaviour, regardless of feedback type. A positive interaction was found between egoistic values and having been asked to set a high goal. Most participants preferred monetary feedback over the other types, with feedback preferences being explained by gender, age, education and value types.

4. CONCLUSION

On average, the different types of energy feedback were equally effective in motivating energy conservation. This is striking considering the large difference in respondents' stated preference for the feedback types. We find that individuals with egoistic values seem less willing to reduce their energy consumption, unless in the monetary feedback or high goal conditions. Individuals scoring high on altruistic values were not more willing than others to reduce their energy consumption in response to environmental feedback, yet in response to monetary and kWh feedback. Individuals scoring high on biospheric values were more likely to reduce their energy consumption within all feedback conditions and their motivation did not increase in response to setting an energy conservation goal. An effect of a high goal was found only when combined with monetary feedback. No effect was found for the low goal level. Setting an energy conservation goal of 10% may thus be an effective intervention when combined with monetary feedback – in particular for individuals that score high on egoistic values.

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Not only experts matter: The role of lay people's expectations about the energy future in acceptability evaluations

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Keywords: public acceptance, public support, expectations, energy transition, survey, Switzerland

ABSTRACT

Public support is a key enabling factor for the transition from fossil-fuel based energy carriers to renewables. Accordingly, many empirical studies focus on public support for energy policies or energy infrastructure, see for example [1] for an overview. These studies identify a range of contextual (e.g., risks, benefits fairness, and spatial proximity) and psychological factors (e.g., place-attachment, trust, and individual values) that shape public support. One aspect that is usually not considered in these studies are individuals' expectation, which have shown to play a key role in explaining decision-making processes of experts in the energy system, see for example [2] for an overview. Even though the broader population might not have a comprehensive understanding of the constraints and interdependencies of the energy system, this does not equal an absence of personal meaning of or beliefs towards energy technologies or systems. In fact, also lay people have strong and differentiated opinions about the energy future, which can in turn shape their perception of energy technologies and policies. Consequently, as the decisions related to energy system and infrastructure planning are no longer purely technocratic in most countries, expectations of lay people may indeed be relevant for understanding public support for energy transitions.

In order to explore the energy-related expectations of lay people, we conducted an online survey among the German-speaking population of Switzerland. Participants were recruited via the online panel Respondi. The online survey was programmed using the software package Unipark. The sample approximates the characteristics of the Swiss population in terms of age and gender, as we screened participants by quota on these two dimensions at the beginning of the survey. In total, 643 respondents completed the survey,

Switzerland is an interesting case to study public support for renewable energy technologies. The direct-democratic political system of Switzerland allows for collecting and comparing data in a realistic setting because voters can express their preferences about energy policies or infrastructure projects at the ballot box on a national, cantonal and municipal level. Furthermore, in May 2017 a majority of Swiss voters passed the so-called Energy Strategy 2050 into law. While the public supported this governmental energy strategy overall, the policies and infrastructure projects that are necessary to implement it are not without controversy.

We assess the relevance of expectations for the acceptability of energy technologies and energy policies using an explorative research design. For that, we combine the respondents' expectations with

their support for energy technologies in general as well as their approval of concrete expansion options. More specifically, one block of questions intended to capture the respondents' vision of the energy system, i.e. how they expect it to change until 2050 in comparison to today. These items refer to characteristics of the energy system that play a role in the current debate about the Swiss energy transition and are adapted from [3]. While some of them represent continuous developments (e.g., the share of renewables), others represent changes in frequencies of events (e.g., blackouts). In addition, we included the 12-point *Consideration of Future Consequences* scale to measure how much a participant is considering distant future consequences in general, which provides a complement to the more energy specific expectations [4]. In order to be able to compare our results to existing public acceptance studies in Switzerland and other countries, we measure the level of support for different energy technologies using established methods and question blocks, as for example used in [5], [6], [7]. Finally, we measure demographic characteristics of participants, including political ideology and trust in institutions.

Regression results show that expectations are good predictors for energy transition support, but are less important for the support of particular technologies. In addition, we will show how the long timeframes that are typically associated with energy infrastructure impact their acceptability. Furthermore, the study could shine a light on whether and how people reconcile their idealistic preferences for the future energy system with their sense for the prevailing political and economic realities.

Overall, our findings suggest that gaining public support for energy transitions on a general policy level does not automatically lead to support for concrete energy technology expansion options because different decision-making processes and heuristics matter for the latter. More concretely, support for an energy transition seems to resemble many other policy campaigns in the sense that political ideology and the publics' interest in a future that is in accordance with their values and expectations can cause greater policy approval. In contrast, support for energy technology expansion proposals that would require immediate trade-offs are less influenced by abstract life goals and values. These results thus provide insights on the multi-level governance of energy transitions and the acceptability dynamics between national energy policies and the required implementation of local energy infrastructure projects.

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WILLINGNESS TO ADHERE TO SMART GRID WITH DYNAMIC PRICES, ENERGY LITERACY AND FAMILIARITY WITH PEOPLE AND TECHNOLOGY

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Keywords: Smart Grid; Willingness to adopt; Energy Literacy; Consumer Trust.

ABSTRACT

The envisioned the smart grid with dynamic tariffs [1], under development by researchers, endows consumers with a more active role [2], and conceivably enlarges the context of their energy behaviors while pursuing everyday activities and goals. A focus role is to become conscious consumers by monitoring energy use and pursuing higher efficiency and conservation, but the potential is there for other roles (e.g., to become microproducers, or agents of preferences, namely for renewable energy sources) in making choices of energy products and services, including choices of adopting ICT 'smart' technologies at home. Moreover, the new roles involve perceived relations with energy providers firms and other agencies and institutions. Envisioning this change is conceivably complex for them, given that the high degree of integration may defy their perception of control over needed actions and/or solutions to achieve a successful adaptation.

The assumptions in this paper, premised in literature on general consumer processes are (a) accessibility of justification for the change is relevant to the attitude and to motivation [3, 4]; (b) trust beliefs and feelings towards meaningful agents to consumers in accord with their values, in the market, regulation and social-institutional spheres [3, 5], will matter; (c) trust beliefs and feelings towards technological means [6, 7] which can be used by consumers will also play a role in how their prospectively envision the change. Given that one important social justification is the goal of sustainability, the attitude is expected to be more positive when supported by literacy factors, by which term we mean a sense of familiarity with several energy issues overlapping with sustainability concepts. Consumers' understanding of sustainability issues and policies in general is believed to have an influence on proenvironmental attitudes, as it provides 'information about the reasons for engaging in proenvironmental behavior' [8], [9]. Assuming that adapting to the smart grids with dynamic prices represent a challenge for the consumer, potentially arising uncertainty, feelings of risk, along with consideration of probable positive outcomes, trust issues in regard to agents with perceived roles in the implementation process and to the technology may be of importance [10]. Trust is "*willingness to rely on another on the basis of confident and positive expectations towards others and their intentions or behaviour*" [11], and confidence "*the belief, based upon experience and evidence, that a future event will happen as expected*".

The goals of the study are: (1) To obtain qualitative and quantitative descriptive data on participants' energy literacy on issues including familiarity with the existence of peaks and empty periods, costs in invoice, energy prices and tariffs, energy labelling, electricity providers, and familiarity with smart meters; (2) To analyze associations between energy issues literacy, energy conservation behavior, familiarity with and trusting perception of agents, experience with and trust in technologies, on the one hand, as predictors, and two target variables of *Willingness To Adhere To Smart Grid With Dynamic Prices In Order To Use Electricity Off Peaks*, and of a set of *Positive Trusting Feelings Towards It,* on the other hand, as criteria variables, through multiple regression analysis and (3) to discuss implications on relevant targets for educational and other interventions.

An online questionnaire was sent to 571 consumers enrolled in a market study firm, comprising

closed and open questions about energy issues, including asking for short descriptions about what they thought smart meters were and did, and demanding their thoughts upon reading short descriptions about them, about smart grids with dynamic prices, and smart efficiency technologies to use at home. Closed questions were asked about familiarity with and trust beliefs in energy provider firms, energy regulator and consumers' protection association. Closed questions about experience with generic kinds of technology and trust beliefs in three different technological devices to use at home varying in degree of automation were included. Energy behaviors at home and Sociodemographic variables were also assessed in a quantitative approach.

The main result from the quantitative analyses is that the variables of *Willingness To Adhere To Dynamic Prices Grid For Consuming Off Peaks* and *Positive Trusting Feelings Towards It* are correlated with a large set of variables, namely experiences with general types of technological devices, familiarity and trust in Consumer Protection Agency, in Energy Provider, and in Regulating Agency, and with consumer energy conservation behaviors. Each of the two target variables is however explained by a smaller set of predictors, most prominently Trust Beliefs in Technological devices, literacy issues such as calculation of monthly electricity invoice, and, in the case of *Positive Trust Feelings to the grid*, perception of trust in the Regulating Agency.

While experience with, and trust in, several technology devices figure as conditions for a promising path to adherence, directly supporting adherence, other variables of interaction and familiarity with agents may be influential through affect towards the new Grid. Conservation behaviors and literacy with energy issues are also facilitative of acceptation of the change. Qualitative analyses results are suggestive that the attitude to this target is multidimensional.

The role of both experience, attitudes and affect to technology, and to several agents involved in energy management is a major finding of the present study, suggesting that consumers make their attitude contingent on perception of a favorable context of a higher dimension in comparison to that which is the setting for their efforts to manage energy use at home.

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Are energy decisions about energy?

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Keywords: Energy renovation, socio-technical approach, private homeowners.

1. INTRODUCTION

Research shows that buildings should use 80% less energy in 2050 to counter climate change and to reduce dependence on fossil fuels [1, 2]. To achieve this in the Netherlands, 75% of the Dutch houses should be renovated [3] with a pace of 300,000 houses each year [2]. This can be achieved by one-off energy renovation measures such as insulation, efficient heating and ventilation systems or renewable energy production. Despite the technical potential and widespread policies for supporting energy renovations [4], the energy renovation pace is not on schedule to meet the emission targets [5].

From a techno-economic perspective, a significant amount of research has been conducted on energy renovations concerning private homeowners' willingness, interest and motivation. These studies have identified important factors and motivations which influence choices homeowners make about decisions concerning energy renovations. However, this research provides little insight into the context in which these choices are made, how they are experienced by the homeowners, and what their perceptions are on these experiences and choices. There is also little known about the role of advice from people in their social network or advice from professionals.

Regarding social science and psychology, research shows that individual behaviour towards pro-environmental behaviour depends on a large number of different factors such as norms and values, habits, experiences, knowledge, awareness and their context. Nevertheless, such studies are mainly focused on daily energy saving behaviour and not on high-impact one-off energy renovation measures.

A more comprehensive understanding is needed on how choices are made and what the rational is behind them, one that goes beyond the economics of energy choices, awareness, attitudes and behavioural control. This understanding is required to make policy and market introduction of energy renovation products more effective [4]. Therefore, this research aims at developing an interdisciplinary socio-technical approach that goes beyond technology and individual behaviour but will also tackle the physical, economic and social context of homeowners.

2. RESEARCH METHOD

In this study, three Dutch initiatives for private homeowners from municipalities in the city region of Parkstad Limburg are used as case study to collect empirical data. This region is selected since it is one of the frontrunners on energy strategies in the Netherlands. This region locates 8 municipalities and counts 125,885 households [6]. This study focuses on owner-occupied homes because this group forms the majority (54% in Parkstad [7]). Empirical data was collected by 52 semi-structured face-to-face interviews with homeowners who have carried out recently energy renovation measures, and homeowners who have not done so. The interviews comprised mostly of open questions and were conducted in the their homes. Questions covered details about their experiences with and perceptions towards energy renovations, how information was obtained, the implementation of measures, how they were financed and why, motivations, experienced changes and future plans. Interviews were digitally recorded and transcribed and qualitative analysis software (Atlas.ti 8) was used to systematically analyse the transcripts using Evers' "thick analysis" method [8].

3. RESEARCH FINDINGS AND CONCLUSIONS

The first findings of this study show a wide range of homeowners' motivations for energy renovations with most homeowners stating multiple motivations. The most common ones are: decreasing energy use and costs, improving thermal comfort, and environmental concerns. An important motivation for older homeowners (60+) is increasing the sales value of their home. Reported reasons for not opting for certain measures are high investment costs, uncertainty on energy savings and having too much inconvenience in the house.

Furthermore, homeowners express the need for professional, objective advice focused on their specific situation. Related to receiving advice, homeowners point out that they find it more trustworthy as a product or company is recommended by someone they know. They stated that people in their social network influenced their decisions by giving advice and sharing their experiences. Other findings show that homeowners who have implemented measures in their home, have experienced a positive change in their home afterwards, for example a lower energy-bill and improved thermal comfort. They also indicated that they have shared these positive changes with friends and family. Overall, sharing experiences with energy renovation measures in a social network seems to be an important influencer in homeowners' energy decisions.

The findings reveal new entry points for policy action such as ensuring homeowners receive credible advice on energy renovations focused on their specific situation and supporting the sharing of experiences with energy renovations in social networks. The results also show that energy renovation decisions are not about energy in a simple way but that energy renovation choices are being assessed by homeowners from various perceptions with an important role for persuasion.

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Towards a sustainable agro-food INDUstry: Capacity building programmes in energy Efficiency (INDUCE).

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Keywords: Capacity building; Energy Management; Behaviour change; Organization behaviour; Design Thinking

TOPIC

Development and implementation of energy management training programs in 15 pilot companies, followed by large-scale roll-out, aimed at energy efficiency, energy savings, and the adoption of low-carbon technologies in the European agro-food sector. The training programs will focus on influencing behavioural and organizational aspects while taking into account the cultural context.

ABSTRACT

We will present proceedings from the H2020 project INDUCE, that has started February 2018. Since results from the fieldwork are not yet available, this abstract focuses on the problem addressed by the project, the chosen methods to tackle this problem, and the rationale for the approach backed by scientific literature. In September 2018, at the conference, we will be able to discuss first results.

The INDUCE project was developed in response to a Horizon 2020 call for "Staff trainings and capacity building programs to enhance corporate policy towards energy efficiency, energy culture (motivations, behaviour change, mitigation of perceived risks and barriers) and sustainable supply-chain initiatives." The INDUCE project was selected because its approach has three unique features. Firstly, it focuses on human and organizational behaviour as the key to establishing an organization culture in which energy efficient behaviour is the norm, or the 'default' as Thaler and Sunstein [3] would call it. Secondly, rather than just finding and sharing proven concepts, it aims for large-scale roll-out of evidence-based training and capacity building interventions as part of the project. Thirdly, the project takes a so-called Human Centered Design approach, implying close cooperation with the end users of the results throughout all phases of the project.

The project focuses on effective implementation and use of Energy Management Systems (EMS) in companies. An EMS enables a company work towards an energy efficient culture at all layers of an organization, provided that it is integrated in company decision making – not just on capital investment in energy efficient technology, but also on automation/optimization, and "good housekeeping". Approximately 50% of the untapped energy efficiency potential is related to structural and behavioural change [4]. Ultimately, the effectiveness of an EMS relies on board and employee behaviour, which in turn is shaped by the organizational processes, structure and context (culture), both within (internal) and around (stakeholders, supply chain). This, however, does not happen just automatically when a company implements an EMS, even if they have it certified (e.g., ISO50001).For this reason, commercial energy advisors increasingly see the need to focus more strongly on human behaviour and organization culture in their advice and trainings.

In recent years, several energy advisors have developed and tested training programmes aimed at organizational and behavioural change. At present, however, many advisory services still lack the expertise needed to develop effective behavioural and cultural interventions. At the same time, demand for these interventions is present, but often 'hidden'. Therefore, INDUCE focuses on large-scale rollout of proven concepts and on establishing a community of trainers able to use the INDUCE

training and capacity building tools and methods. We thereby hope to contribute to faster expansion of the market for evidence-based and practice-based energy advice.

INDUCE follows a Human Centered Design approach, marked by three phases: Inspiration, Ideation, and Implementation. The Inspiration phase, which we just described is currently in progress and will take roughly until March 2019. Proceedings of this phase will be presented at the BEHAVE 2018 conference. In the Ideation phase, the results will be processed to develop (or fine-tune existing) training materials and tools, which will be tested and validated in the same 15 pilot companies. In the final phase – Implementation, a community of trainers will be established by certifying 60 INDUCE trainers. They will be in charge of implementing INDUCE methodology in another 300 companies, hence increasing INDUCE impact up to 106 GWh/year of energy savings.

To achieve this impact, four countries participate in INDUCE that represent over 45% of the EU companies in the agro-food sector: Spain, France, the Netherlands and Germany. In each of these four countries, partners were selected that can cover three roles: a knowledge institute, a training company, and a multiplier organization with an excellent network in the sector. The consortium is completed by a research oriented SME focussed on exploitation and dissemination. By the end of the project, a network of energy experts, trainers and consultants will be available for companies who are experienced users of the INDUCE toolkit and can help companies establish an energy efficiency culture. Finally, while the agro-food sector is central to the project, it is expected that the lessons learned will translate to other sectors, thus increasing its potential impact even further.

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RESEARCH-BASED COMMUNICATION STRATEGY TO BOOST ENERGY EFFICIENCY IMPROVEMENTS IN MULTI-APARTMENT BUILDINGS

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Keywords: Energy efficiency, Multi-apartment buildings, Communication

1. INTRODUCTION

The Government of the Republic of Croatia adopted in June 2014 the Programme for Energy Renovation of Multi-apartment buildings (MAB) the period 2014-2020. The Environmental Protection and Energy Efficiency Fund was designated as the implementing body of the Programme. During the first implementation period 2014 - 2016, the Fund published public calls for co-financing energy renovation of MAB according to the Program, which resulted in enabling renovation of 430 MABs. The next phase of the Programme envisages co-financing from the European Regional Development Fund (ERDF) in accordance with Croatian Operational Programme “Competitiveness and Cohesion” (OPKK). The first call for proposals for using ERDF co-financing was announced in late 2016, based on which co-financing for energy renovation of 596 MABs has been approved.
The response to calls for co-financing energy renovation of MABs clearly demonstrates that there is a significant interest among apartment owners in Croatia for energy efficiency improvements. Energy renovation is recognized as an opportunity to reduce household expenditure on energy, but also as a measure to improve living conditions and increase real estate value.
However, given the fact that there are more than 290.000 MABs in Croatia, with more than 90% of them built before 2005 with none or very poor thermal protection requirements [1], the potential for energy savings is huge and its utilization should be strongly boosted by policy measures other than co-financing. With the aim of creating effective communication strategy that will additionally boost the interest in energy renovation of MABs, the Environmental Protection and Energy Efficiency Fund has launched a research on the attitudes, knowledge, level of awareness and motivation of apartment owners in MABs related to energy efficiency and energy renovation. The research and its results are presented in this paper together with main lessons learned that may be used in definition of communication activities towards this target group.

2. RESEARCH METHODOLOGY

The research was based on the survey among two target groups: 1) apartment owners in MABs that were already energy renovated and 2) apartment owners in MABs that are not yet renovated but have applied for co-financing. The survey was conducted through online questionnaires and telephone, and its aim was to gain insight into the habits, knowledge and attitudes of apartment owners in MABs.
The total number of respondents in the survey was 324, out of which 99 respondents live in MABs that have already been renovated. The other 225 respondents participated in a call for co-financing and the energy renovation of their buildings has not yet been completed. Data about age, sex, education level, number of household members and household incomes were asked for to enable investigation of

possible correlations between energy efficiency related attitudes and these factors. The survey was structured in the following sections: 1) habits of apartment owners related to energy consumption (heating systems, heating fuels, heated space temperature, regulation of in-door temperature, heated area of apartments, monthly bills for heating – for the first target group these data are asked for period before and period after the energy renovation); 2) self-assessment of energy efficiency related behavior (set of energy efficient behavior examples is given and respondents provided grading of their own behavior); 3)motivation for energy refurbishment of buildings (factors that motivated apartment owners to undertake energy renovation or to apply for co-financing were asked for but the opinions on who should promote energy renovation of MABs and provide all information to apartment owners about energy renovation and possibilities for co-financing was also investigated); and 4) perceived/expected benefits from energy renovation (relation between expected and realized energy and cost savings was investigated, as well as other benefits like real-estate selling value, reduction of in-door moist, mold and drafts). The survey was performed in November and December 2017.

3. RESERCH RESULTS

The responses to the survey questions are analysed and elaborated in the report "Analysis of citizens' motivation for the implementation of energy renovation of multi-apartment buildings and analysis of realized impacts" [2]. The main findings per each survey section are as follows: 1) The least knowledge of respondents is perceived in relation to heating fuels and systems – while they demonstrate fairly good understanding of issues related to thermal insulation of building envelope, they much less understand the possibilities for energy efficiency improvements in heating systems and in space heating related behaviour; 2) this is also confirmed by self-assessment responses, which revel that respondents do not relate their behaviour with energy and cost savings (e.g. reducing heating temperature or turning off the heating when no one in in the apartment); 3) the most important motive for starting the energy renovation process according to the respondents is a reduction in the heating bill and a healthier and more comfortable housing and 4) the respondents that have undergone the energy renovation process of their MABs confirm that these benefits are achieved. Additionally, most of the respondents see the building mangers and representatives of apartment owners as crucial for motivating other apartment owners to decide on energy renovation.

4. CONCLUSIONS

Based on the research results, the recommendations for creation of communication strategy are given. It is recommended to emphasize the high share of space heating in total household energy consumption in promotional materials and to educate apartment owners how with simple behavioural changes they can achieve significant energy and cost savings. Reduction in the heating bill and a healthier and more comfortable housing should be the main framework for communication campaign. Communication materials should be informative, relieved from any complex technical details, enabling apartment owners to clearly recognize their benefits from energy renovation.

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Competing priorities: Lessons in engaging students to achieve energy savings in Universities.

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Keywords: Behaviour change, energy efficiency, universities, feedback.

1. INTRODUCTION

This paper presents findings from an EU funded international student-led energy saving competition (SAVES) on a scale previously unseen. There are multiple accounts of short-term projects and energy saving competitions encouraging pro-environmental behaviour change amongst students in university dormitories but the purpose of this research is to provide evidence of consistent and sustained energy savings from student-led energy savings competitions, underpinned by practical action. It presents findings from a three-year EU Intelligent Energy Europe (IEE) funded project SAVES (Students Achieving Valuable Energy-Savings) which encompasses an inter-dormitory energy-saving competition involving dormitories in seventeen European universities over two academic years: 2014/15 and 2015/16. At the heart of the SAVES project is an energy-saving competition called Student Switch Off. The Student Switch Off (SSO) campaign was set up by the National Union of Students of the United Kingdom (NUS-UK) in 2006 and encourages students to save energy and motivate their flat mates to do the same. Over the academic year the SSO campaign incorporates a variety of offline and online events, peer mentoring and individual competitions to keep awareness as high as possible and distributes prizes, both at the individual and group level, to keep pro-active students motivated. These include fortnightly photo competitions themed around different energy-saving actions where students post photos on their university SSO Facebook fanpages to win prizes; dormitory visits; communication skills training (to give proactive students, called SSO ambassadors, more expertise to act as peer mentors and encourage their friends to save energy) and online climate change quizzes.

2. METHODOLOGY

The contribution of this paper is the scale of data gathered in order to be able to generate findings with regards to the effectiveness of these types of interventions. A mixed-methods approach was utilised in order to evaluate the level of electricity saved and the impact on behaviour. This took the form of pre and post intervention surveys, electricity meter readings and focus groups. Behaviour swings are indicative of the impact that the SSO campaign has had on students and that has led to the reported energy savings. The sampling frame for the calculation of energy savings consisted of dormitory buildings used as student accommodation in five different European countries: Cyprus, Greece, Lithuania, Sweden and the UK. In the intervention group this amounted to 17 different universities, housing 24,976 students over the academic year 2014/15 and 30,349 students in 2015/16 (55,325 students in total over two years). Baseline electricity data were collected for each of the participating dormitory buildings for the 2013/2014 academic year; in universities where SSO was run in years prior to 2013/14, the baseline was formed from the year prior to the campaign starting.

Table 1: Energy Savings by Country

Energy usage and savings per country

2014-15

	UK	Greece	Cyprus	Sweden	Lithuania	TOTAL
Baseline usage (kWh)	19,349,583	2,070,276	233,210	3,110,500	4,220,787	28,984,356
2014-15 usage (kWh)	18,334,297	2,016,552	217,067	2,735,296	4,157,609	27,460,821
kWh saving	1,015,286	53,725	16,142	375,203	63,179	1,523,535
% saving	**5.25**	**2.60**	**6.92**	**12.06**	**1.50**	**5.26**
CO2 saving (kg)	545,696	38,682	11,816	6,378	15,678	618,251

2015-16

	UK	Greece	Cyprus	Sweden	Lithuania	TOTAL
Baseline usage (kWh)	20,340,014	1,660,781	244,154	2,706,120	4,152,605	29,103,674
2015-16 usage (kWh)	18,650,358	1,645,797	143,443	2,376,600	3,739,449	26,555,647
kWh saving	1,689,656	14,984	100,711	329,520	413,156	2,548,027
% saving	**8.31**	**0.90**	**41.25**	**12.18**	**9.95**	**8.76**
CO2 saving (kg)	908,156	10,789	73,720	5,602	109,176	**1,107,443**

Three surveys were used to identify changes in energy awareness. Pre and post intervention surveys were used to determine changes in energy awareness for those living in dormitories over the two years. 6,907 students gave their consent by providing their email in the baseline survey. The total number of responses for the follow-up survey was 1,541. From those 1,541 respondents, 1,358 were matched to respondents of the baseline survey and were considered for the pre/post comparison test. A further third questionnaire survey was also conducted with students who lived in participating dormitories in 2014/15 but moved into private accommodation in 2015/2016. The aim of this survey was to help identify whether the energy-saving actions established during their time in dormitories had been carried forward. The survey was sent to all students that responded to the follow-up survey the previous academic year (613 students). Overall, 98 valid responses were collected and included representation from all five countries. In addition, five focus groups were held in each country with 53 students attending in total across the five countries.

3. KEY FINDINGS AND CONCLUSIONS

This Europe-wide project shed further light on the role and potential of student-led campaigns, underpinned by practical action, and competitions with neighbouring dormitories that led to sustained energy reductions. Whilst other interventions have shown greater savings, this three-year project across five countries provides clear evidence of consistent electricity savings of 7% across a large number of universities through simple behaviour changes. Out of the six targeted energy saving actions, a statistically significant increase was observed in the frequency that students state they performed the less well-known energy saving actions, namely putting a lid on pans when cooking and boiling only the right amount of water in both years. In the first year of the project a significant increase was observed in the frequency that electronic appliances are turned off as well. On retention of behaviours, 68% of the respondents no longer living in dormitories said that when living in dormitories their awareness on how to save energy had increased as a result of information/posters/messages students received from the Student Switch Off campaign. The fact that 99% of those who had taken action to save energy as a result of SAVES stated that they were still carrying forward those actions six months later when living outside of dormitories adds weight to the argument that this is a fruitful time to engage with students to encourage pro-environmental behaviour change.

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THE CENTRAL ROLE OF MIDDLE ACTORS IN RETROFITTING SCOTLAND'S BUILT ENVIRONMENT: FOCUSING ON LOCAL AUTHORITIES AND THEIR DELIVERY PARTNERS

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Keywords: Retrofit, Energy policy, Middle actors, Qualitative interviews, Local authorities, Energy efficiency

1. INTRODUCTION: RETROFITTING FOR ENERGY SYSTEM TRANSFORMATION

Scotland's Energy Efficiency Programme (SEEP) is a large-scale nationally coordinated retrofitting programme, intended to run over 15-20 years. SEEP includes energy efficiency improvements and the decarbonisation of heat. The Scottish Government have positioned this as the cornerstone of efforts to decarbonise the built environment [1] and to meet carbon budgets to 2032 [2]. SEEP is currently undergoing two pilot phases. The first, commencing September 2016, has involved nine Local Authorities (LA) undertaking retrofit projects; the second, commencing September 2017, has included an additional ten LA-led retrofit projects. In this pilot programme, LAs bid for funding to perform area-based retrofit projects, and then organise a network of delivery partners and sub-contractors to assist in delivering the retrofits. Delivery partners are charities or not-for-profits who have expertise and trusted reputations in delivering energy efficiency programmes. It is the skills, responsibilities of and relationships between the LAs and their delivery partners that provide the focus of our paper.

2. THEORY: MIDDLE ACTORS AND PROFESSIONS

The importance of authorities, contractors, and construction professionals for delivering building policy aims has been documented (cf. [3], [4]) and the 'Middle-Out Perspective' (MOP) draws our attention to the upstream, downstream, and sideways influence that these agents of change can have [5]. In this analysis, we focus on sideways interactions, or the ways in which various professions and organisations in 'the middle' can interact and influence one another. For this, we draw on Abbott's System of Professions [6], which considers the ways in which professions define and maintain their jurisdiction, or identified work tasks. Our primary concern is with how responsibilities are allocated and negotiated between the LAs and delivery partners involved in complex retrofitting projects.

3. METHOD: EVALUATING THE DELIVERY OF BUILDING RETROFITS

The data for this paper is taken from a three-year socio-technical evaluation of the SEEP retrofit pilots, which commenced in November 2016 (see [7] for detail on the full evaluation). This analysis draws on in-depth interviews carried out with the nine LAs taking part in Phase 1 of the SEEP pilots. A total of 18 in-depth interviews have been carried out: two with each LA. The first was conducted approximately six months after the LA commenced the pilot project (Spring 2017), whilst the second was carried out approximately one year later (Spring 2018). All of the interviews were between one hour and 90 minutes long. Eight of the nine LAs worked with delivery partners for different aspects of the SEEP projects; it is these interviews that have been analysed according to two themes: distributed expertise and negotiated responsibilities.

4. FINDINGS: SKILLS AND NEGOTIATON IN THE MIDDLE

4.1. Distributed expertise in the middle

The LA SEEP pilots utilised project management processes established through previous retrofitting programmes. They often chose to commission delivery partners to take on certain functions of the project rather than retaining the relevant skills and resources for these functions in-house. For example, one LA retrofitting manager noted that delivery partners are: "*good at the private engagement. [This is] something we don't get involved with....it shifts the risk around as well. It's not all risk for us.*" Thus, one of the themes we explore is *where* retrofitting expertise lies, and *how* this distributed expertise allowed LAs to utilise delivery partners' specialist skills for successful pilot delivery, in this case, through spreading risk.

4.2. Negotiated responsibilities between middle actors

The 'area-based, cross-sector' approach required for SEEP pilot funding also required innovating beyond established retrofit processes to reach more diverse buildings and occupants. LA officers established new ways of working with existing delivery partners, but new roles were often contested. For example, one LA interviewee discussed the volume of housing information that the partner held, noting that this put them *"in that position to be the natural partner that can come in and say, 'well look, you can do this here' [but] not having that in-house function was limiting as well."* He queried the loss of 'in-house' LA capacity, which limited their flexibility to identify suitable projects for SEEP. Moving beyond existing delivery programme remits brought in questions about distribution of responsibilities and skills between these middle actors, and consequences for energy saving.

12. CONCLUSIONS

Local authorities and their delivery partners are critical middle actors in realising the Scottish Government's ambitions in SEEP. Previously established ways of working have allowed expertise to accumulate in delivery partners across multiple local areas, to complement the skills and resources held within local authorities. However, as national policy drivers require new and more flexible ways of working, the existing lines of responsibility and skills distributions are being challenged and re-negotiated. The sideways interactions of these middle actors will be critical to the successful delivery of national policy objectives.

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NEW OPERATIONAL CHALLENGES IN ELECTRICAL DISTRIBUTION NETWORK MANAGEMENT IN PRESENCE OF STORAGE SYSTEMS

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Keywords: Electrical Distribution Network, Operator, Storage Systems

1. INTRODUCTION

The wide spread of Distributed Energy Resources (DERs) in electricity Distribution Networks (DNs) may affect security and quality levels of the energy supply. To overcome these issues, Distribution System Operators (DSOs) have to adopt control solutions which make the network management more complex than today's one. Meanwhile, DSOs are considering Energy Storage Systems (ESSs) as an interesting option, testing them all over Europe [1], even if ESSs still lay in the "grey area" of bill remunerated assets. In 2010 the Italian National Regulatory Authority sustained a set of pilot projects in order to deep examine the advantages in terms of network flexibility that ESSs' employment could fulfil. In [2] a methodology was proposed for providing an optimal management of this device, respecting different goals (reduction on losses, etc.), of multiple connection points for an ESS in a Medium Voltage (MV) grid. A rank of best solutions is then proposed to the operator at the DSO centre. In this case the worker has a new responsibility; it consists in applying the definitive choice that mixes the best theoretical technical-economic answer with the former practical knowledge and skills. In this paper the optimization methodology and the interaction between systems and human operators are explained.

2. METHODOLOGY

The overall context considers the presence of a centralized control platform, developed in Matlab, for each High Voltage (HV)/MV substation. For each time interval (commonly every 15' or after triggering events), it optimizes, according to the grid topology and load/generation forecast profiles, the network state in term of voltage, current flows, active power losses, ESS charge, etc. In case of violations, set point commands are sent to the available distributed resources (e.g. HV/MV transformers' tap changers, controllable generators and ESS) based on a specific economic weight (i.e. cost). The algorithm is also able to compare the different ESS connection alternatives according to selected targets (commonly active power losses reduction). Recent developments have selected, as one of them, the Lagrange multipliers evaluation, in order to avoid solutions that, even if acceptable, are close to an instability state. The outputs of the algorithm consist in different sets of ESS configurations, ranked on the basis of targets (Figure 1). They are then sent to the network operation centre and, via the interface, to the human operator. At this final step the action is demanded to the network operator who has the responsibility to choose the best solution, basing the decision not only on the calculated technical-economic process but also on the practical experience.

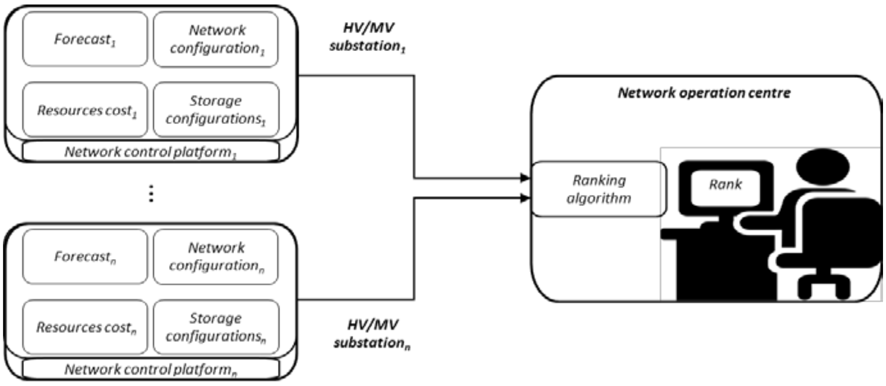

Figure 1: Flow diagram of the procedure for the calculation of the optimal ESS connection point

3. OUTCOMES

Test phases have been conducted on different MV networks by offline and online stages. All of them, considering different ESS connection settings along a day, and the impacts on grid operation parameters (e.g. active power losses), have demonstrated the effectiveness of method (Table I).

Table I: Power losses reduction in a test network (offline, 3 feeders with a PV, 2 ESS connection options)

ESS connection node #	*Periods (15')*	*% Active Power Losses reduction*
no ESS (baseline)	1 ÷ 96	Reference
A	1 ÷ 96	-1.2%
B	1 ÷ 96	-2%
Multiple connection (in sequence)	1÷56 + 57÷64 + 65÷71 + 72÷96	-3.5%

It can be seen how the optimal sequence, based on the ESS' charge constraints and on the forecasted evolution of the system (load, generation), is rather complex. The calculated setpoint is then not intuitive, causing possible indecision in the operator's action. For this reason, there is the necessity of a specific training for workers on the algorithm, as yet considered by DSOs, one of the most challenging issues towards the adoption of smart grid solutions.

4. CONCLUSIONS

New challenges deriving from the integration of distributed generation impose the adoption of advanced strategies to operate electricity networks, and the utilization of innovative devices like ESSs. In this framework, human operators have to develop new skills to manage efficiently these complex algorithms; one of them concerns the choice of the best ESSs configuration in case of multiple connection points. This aspect represents an improvement in technical issues, but, at the same time, it consists in a further responsibility that weighs on workers.

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A META-ANALYTIC APPROACH TO UNDERSTAND THE PSYCHOLOGICAL CORRELATES OF ENERGY-RELATED BEHAVIOURS

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Keywords: Energy behaviour, pro-environmental behaviours, identity, emotions, attitudes, values

1. INTRODUCTION

Environmental global changes, such as climate change, global warming, biodiversity loss, or the depletion of natural resources have increasingly been in the focus of the scientific, political, economic and social world over the last three decades. Understanding the impact of human action and lifestyles upon the quality of our living environments, and of the natural resources therein, is therefore a crucial challenge for present times. The individual and social determinants of environmentally friendly human actions are currently in the focus of environmental and social psychological investigation, in various behavioural domains, including energy-related choices. Although disciplines like psychology, sociology and economics have extensively studied the mechanisms driving human energy choices still, there is a gap between psychological factors identified in earlier studies and people's observed and actual behaviours in the energy domain. In this work, we present the results of two meta-analyses (MA) that assessed, respectively, the link between social identity factors and pro-environmental behaviours in general (Meta-analysis #1, N = 58.207; K = 125) and the links between individual levels factors and energy-saving behaviours (Meta-analysis #2; N = 59.948; K =102). Based on a systematic review of published studies we estimated average effects size of predictor-criterion relations, publication bias, and relevant moderators for both MAs.

2. A META-ANALYSIS ON SOCIAL AND PERSONAL IDENTITY VARIABLES PREDICTING PRO-ENVIRONMENTAL ACTION

Identity processes are increasingly recognized as potential drivers of pro-environmental action. This is true for different types of identity variables, such as social identity, environmental identity, connectedness to nature, and place identity. As social and personal identity effects on pro-environmental action have different implications for implementing pro-environmental policies, we were particularly interested in comparing the relative impact of these different kinds of identities. While narrative reviews on some of the relevant predictors have been published recently [1],[2], a quantitative review of the literature has not been available up until now. It is therefore important to systematically evaluate existing research on the links between pro-environmental behaviours and behavioural intentions and different types of personal and social identity. We focus, specifically, on social identity, environmental identity, connectedness to nature, place identity and on their links to pro-environmental behaviours and intentions. The results of our first MA reveal a robust positive link between environmental identity and connectedness to nature on the one hand and pro-environmental behaviours and intentions on the other hand, as well as a moderate relation of place identity to pro-environmental behaviour but not with pro-environmental intentions.

3. A META-ANALYSIS ON INDIVIDUAL LEVEL PSYCHOLOGICAL FACTORS AND ENERGY SAVING BEHAVIOUR

Individual level factors such as ecological attitudes, pro-environmental values, awareness of consequences of behaviour, beliefs in climate change, emotions and intentions to adopt energy saving solutions have been frequently considered as potential antecedences of energy saving behaviour (ESB). Also in the case of the individual-level factors at the basis of the transition towards more sustainable energy consumption and renewable energy sources, a systematic review of the literature considering all of these factors has not been conducted up until now. Thus, our aim here was to systematically evaluate existing solid empirical evidence on the links between all of these factors (i.e., ecological attitudes, pro-environmental values, awareness of consequences, beliefs in climate change, emotions, and intentions to adopt energy saving solutions) and ESB. The results of our second MA reveal a consistent pattern of significant positive associations between individual-level psychological determinants (i.e., attitudes, intentions, values, awareness and emotions) and energy-saving behaviours. Moderation analysis revealed, however, that attitudes are significantly related to self-reported energy-saving behaviour and intentions, but unrelated to actual energy-saving behaviours.

4. CONCLUSIONS

In sum, the results of the current meta-analyses confirm the substantial associations between the individual-level factors investigated and ESB, as well as the substantial policy potential of all studied identity variables for the promotion of pro-environmental behaviour in general. Thus, if policy can contribute to either forming or triggering the social identities, likelihood of pro-environmental behaviour across different domains will increase. All these factors should therefore be taken into account by researcher or policy makers aiming to understand and promote the transition towards more sustainable lifestyles and energy use in the society at large.

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CO-DESIGNING A PERSUASIVE APP PROMOTING A LESS CAR-DEPENDANT COMMUNITY: INTRODUCING THE BELLIDEA LIVING LAB

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Keywords: mobility behaviour, smartphone app, gamification, living lab

1. INTRODUCTION

Cities seek to improve mobility alternatives to car to counteract local and global problems associated with traffic and energy-intensive lifestyles. Usually, they primarily target the development of new infrastructures, such as for example biking lanes, or the improvement of public transport offer. However, frequently structural and regulatory tools alone are not sufficient to break car-dependant habits and produce tangible reductions in car use at the community level. To favour adoption of more sustainable mobility patterns, soft policy measures [1] can strengthen traditional urban mobility management. In particular, novel possibilities are offered by the growing diffusion of ICT tools and smart city programmes, which favour adoption and effectiveness of cognitive-motivational tools [2]. In line with recent understandings of the smart city concept (smart technology, smart people, smart collaboration [3]), the City of Bellinzona (Switzerland) activated the *Bellidea* living lab process. Such a living lab aimed at engaging citizens in co-designing and testing the *Belllidea* persuasive app, which rewards sustainable mobility choices, thus motivating changes in individual mobility behaviour and supporting the whole community in the transition from car-dependency to car-alternatives.

2. THE BELLIDEA LIVING LAB

Living labs are "user-centred, open innovation ecosystems based on a systematic user co-creation approach, integrating research and innovation processes in real life communities and settings" [4]. With this definition in mind, in early 2017 we teamed up with the City of Bellinzona and launched a public campaign inviting citizens to join the *Bellidea* living lab. In particular, we targeted both car-drivers and public transport users, in order to guarantee sufficient diversity and enhance creative discussion. We also explicitly targeted students, elderly people and citizens from foreign communities, with the aim of preventing risks of exclusion of such social categories from effective use of the *Bellidea* app. On average twenty citizens attended the monthly lab meetings, held from April 2017 to February 2018, with a summer break. First meetings were mainly shaped as participatory workshops, dedicated to the exploration of already existing apps, the identification of the key functionalities to include in *Bellidea*, and the discussion on the gamified rewarding mechanics to be activated. Later meetings were instead organized as test-beds for the prototype versions of the app, which were step-by-step released. A website and online forum further supported discussion and reporting errors.

3. THE BELLIDEA APP

The outcome of co-creation in the lab is an app that performs automatic mobility tracking, provides users with eco-feedback on their individual mobility patterns, stimulates them with mobility-related challenges and invites them to collect points, which are proportional to the weekly percentage of travelling time by public transport, bicycle or walking. Points can be redeemed for prizes such as discounts on energy bills and vouchers for local stores and public transport tickets.

Since real prizes are offered, detection of the mode of transport is crucial. Requesting users for a validation, as in many mobility tracking apps, would leave room for cheating. However, current automatic detection capability is limited, with peaks in detection accuracy only reaching 75% of trips [5]. Improved algorithms based on a previous app we had created [6] were thus developed, to implement a mixed configuration: a short training period requires validation for all trips, providing no points; then, validation is only asked when estimated likelihood of the mode of transport falls below a certain threshold. The underlying assumption is a relationship of trust between the app and its users.
Lab participants decided to introduce community prizes as well. To this purpose, *Bellidea* also offers community challenges, to be periodically launched throughout the year, such as «This month, let's use the bicycle for at least 20% of our overall travelling time». If app users achieve such a challenge, the community as a whole gets a prize, such as for example discounts on public transport season tickets, public transport excursions for school classes or cargo-bike transport services for elderly people. We expect that such a mechanics further motivates people to keep level of activity high, since it builds on both their feeling of belonging to the local community and on their desire for attractive prizes.

4. CONCLUSIONS

Co-design of the *Bellidea* app was completed by Autumn 2017, while its computer development is currently ongoing; launch to the whole population is planned for Spring 2018. If we manage to obtain a wide diffusion of *Bellidea*, we expect reductions in mobility-related impacts, at least for systematic trips, as suggested by preliminary results of a similar experiment we run in the same area [6]. Positive impacts will however go further. In fact, *Bellidea* will provide the City of Bellinzona with real life data on the citizens' mobility patterns and create new channels to interact with them: analyzing and discussing such data with the citizens themselves will bring new ideas and points of view in the design of future mobility scenarios. Moreover, if the approach proves successful, the City will be endowed with a new set of governance practices, to refer to also for future decision-making processes.

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USING DIGITAL INTERVENTIONS FOR BEHAVIOUR CHANGE TOWARDS ENERGY EFFICIENT BEHAVIOUR

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Keywords: Energy efficiency, Energy Consumption, Behaviour, Awareness Raising, Digitalisation, Interventions

1. INTRODUCTION

Energy is consumed by people rather than by buildings. However, most of the strategies to achieve energy efficiency in buildings focus on technical mitigation measures. The EU Interreg Alpine Space project 'THE4BEES' aims at reducing greenhouse gas (GHG) emissions and energy consumption in buildings through more efficient behaviour. Having the extended model of normative decision making by Klöckner and Matthies [1] in mind, there are various pathways to influence people's behaviour. According to the model, awareness raising is the first step towards behavioural change. Together with users, energy managers, technical experts and scientists, ICT tools have been developed and are currently tested. Four specified target groups are part of seven pilots: alpine huts, schools, work places and private households. In the end it is the behaviour of students, workers, tourists and residents that will create the impact. The ICT tools should support soft approaches to raise awareness and change energy relevant behaviour. For this purpose, a mix of intervention strategies has been discussed and implemented within the project.

2. IMPLEMENTED INTERVENTION STRATEGIES AND FIRST RESULTS

An intervention is a measure that e.g. aims at changing behaviour. Several interventions such as feedback, tips and advice, additional information, story-telling, unusual usage alerts, comparison and competition, gamification and incentives are discussed in the context of digital intervention strategies. Research strongly recommends to use a mix of several intervention types in order to overcome barriers of changing behaviour and to repeat interventions several times in order to achieve long-term impact [2]. In the course of the project it was decided to use the following intervention methods:

1. Feedback: users and energy managers are informed on an ICT tool about their energy consumption and other measures such as room temperature or air quality via sensors. The sensors were programmed in co-creation processes with the pilots using the open-source electronic prototyping platform Arduino. First results show that Wi-Fi access can be a relevant barrier to this approach. Nevertheless, especially students, but also all other pilot site users are very interested in feedback about their consumption behaviour.
2. Comparison: consumption patterns can be compared within a pilot by the energy manager and based on one user's weekly consumption. Due to complexity of inter-group comparison it was decided to use only intra-user or so-called normative comparison with historical data.

3. Hints and tips: users get hints and tips for taking action depending on the season, target group and consumption pattern. These were developed together with the target group and stongly approved.
4. Unusual usage alerts: on the ICT tool users not only get feedback about the average measurement but also an indicator for “best practice” and “worst practice”. This is still under discussion, as it can also lead to converse effects.
5. Additional information: energy consumption is calculated in carbon footprint (kg of CO_2). This is only used in work place pilots as a reference frame and is still under discussion.
6. Storytelling: in two school pilots, storytelling maps are used to involve students directly in the process. They are used to illustrate co-creation processes and measurements with interactive maps, text, images and other multimedia files. So far, this is a very successful method in the project and students are very motivated to be part of the process and track their behavioural impact.

The above depicted intervention methods are integrated in two digital ICT tools (figure 1): 1) For energy managers, a dashboard was created that is fed by sensors in all rooms of the building. The monitored measurements are, for example, power consumption, room temperature, room luminosity, window opening time. 2) An app has been developed, especially for students, with elements like consumption overview, comparison with last week, hints and tips and an option to rate the current comfort level (happy-neutral-not happy).

Figure 1: Dashboard for energy managers (left) and app for students (right).

When information and communication technologies (ICT) are used to trigger behaviour change a few basic considerations have to be made about channel, design and usability of the tool [3]. The tools are currently tested and continuously developed together with the users within the seven project pilots.

4. CONCLUSIONS

First results provide information on what has to be considered when aiming at changing energy related behaviour [3]. The co-creation process demonstrated the high relevance of participation in terms of involving the target group of a specific intervention to foster positive effects. It also shows that changing processes take a long period of time and interventions should be repeated in order to stabilise the desired effects. It is also important to tailor the interventions to different groups of people according to the strength of their habits, knowledge background, intention and environmental constraints [2].

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SOCIO-ECONOMIC EFFECTS OF INSTRUMENTS TO ACHIEVE REDUCTIONS IN ENERGY CONSUMPTION THROUGH SUFFICIENCY: FINANCIAL IMPACTS AND DISTRIBUTIONAL CONSIDERATIONS

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Keywords: Energy consumption, sufficiency, microsimulation, cost/benefit, distributional effects

1. INTRODUCTION

The reduction of energy consumption through sufficiency is considered instrumental in reaching ambitious emission reduction goals. At the same time, bringing about this change and developing suitable instruments is a challenge. In this paper, we focus on the socio-economic effects of instruments and measures in two areas of sufficiency, i) reduction of living space and ii) reduction of household electricity consumption. In this context, we understand sufficiency as the "modification of consumption patterns that help to respect the Earth's ecological boundaries while aspects of consumer benefit change" [1]. The instruments were developed and analysed in an in-depth research project [2] conducted for the German Federal Environment Agency. The research project [2] identifies the most promising target groups in these two areas, identifies relevant barriers and benefits and assesses reduction potentials induced by the developed instruments. In this paper, we build on this work and carry out a socio-economic analysis of the instruments looking at distributional effects from a household perspective. Rather than asking the question whether and under what circumstances households would carry out the measures, we evaluate their financial impact on different household types *given* they are carried out. Results can inform policy makers which aspects to focus on in communication (financial vs. non-financial), which supporting instruments may be necessary and whether or not, from a social policy point of view, the introduction of these instruments is advantageous.

2. METHODOLOGY AND DATA

To assess distributional effects and financial costs and benefits from a household perspective, we apply a microsimulation tool based on the German Income and Expenditure Survey (EVS), an administrative data source published by the German Statistical Office. The EVS database contains detailed information on income sources, expenditure patterns, other household characteristics, such as age or employment status, as well as information on the dwelling a household lives in, energy carrier used for heating and stock of electrical appliances, which are important to this analysis. The EVS is complemented by energy price projections derived from the German national GHG emission projections.

3. SOCIO-ECONOMIC EFFECTS OF THE PROPOSED INSTRUMENTS

3.1. Reduction of living space

Regarding the reduction of living space the research project [2] identifies retirees or households about to retire shortly as the main target groups. These households face a break in routine and as part of those changes in their lives might be able to accommodate changes in their living situation. To initiate these changes a mix of information schemes (a local office advising households on any housing related issues) and investment support instruments was derived, set to support households in i) splitting their owner-occupied houses into smaller dwellings ii) subletting parts of their homes or iii) moving into a smaller dwelling. While the research project [2] discusses barriers and non-financial benefits and how they may impact implementation rates, this paper focusses on the expected financial impacts, given a household carries out the measure.. In general, the three measures lead to considerable savings and/or additional income, in particular where investment costs are low (i.e. subletting a room, moving into a smaller dwelling). However, even in the presence of considerable investment, i.e. when splitting the home, the additional rental income and savings on heating energy lead to a net benefit for the household. For households on low incomes, the additional rental income represents up to 30% of disposable household income, adding to the 5% of disposable income saved through reduction in energy use.

3.2. Reduction of electricity consumption

Also in the case of reducing household electricity consumption, target groups were identified as households undergoing changes in their lives providing a window of opportunity to induce changes in behaviour. Measures include scrapping a freezer that is no longer necessary (households where children have moved out of the home), buying an adequately sized freezer (young families), saving on electricity used for heating water by showering less often, installing feedback appliances or buying water-saving showerheads or introducing a compulsory power-down for new TVs. These changes in behaviour are achieved by a mix of information schemes (advice, labels) and support for small-scale investments (scrappage bonus, free appliances). Savings are less pronounced than for the reduction of living space, representing, on average, less than 0.5% of disposable household income per measure. For low-income households savings reach 1% of disposable income.

4. CONCLUSIONS

In this paper, we analyse the socio-economic effects of novel policy instruments for the reduction of energy use in households related to behavioural change. The induced measures are generally economically advantageous for households carrying them out and are socially compatible in providing relatively higher benefits to low-income households. In addition to highlighting non-financial benefits, information on financial impacts can be used in communication to overcome barriers. In this context, additional rental income related to the reduction of living space may play a big role, at least for some household groups (e.g. those on low incomes).

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HOUSEHOLD APPLIANCE PURCHASES AS A JOINT-DECISION PROCESS: EVIDENCE FROM UPPER-AUSTRIAN SOLAR ADOPTION[i]

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Keywords: Solar adoption, photovoltaics, energy choices, household appliances, econometrics

1. INTRODUCTION

This research investigates the relationship between household ownership of energy-intensive appliances and solar-adoption decisions. We use household-level data, which includes appliance ownership, to estimate a statistical model of the probability that a household adopts solar. We find that households with energy-intensive appliances, such as electric cars, are more likely to adopt solar technology. This suggests that solar adoption can be viewed as a complementary good to certain other appliances in the household utility-theoretic framework.

For the transition to a low-carbon electricity system to be successful low-carbon electricity must be produced to replace fossil fuels, and citizens need to actively engage with the energy transition. Household photovoltaic (PV) systems overcome both of these challenges as they add low-carbon power to the grid, and get PV owners to invest in the energy transition and consider their energy use more carefully. For these reasons, among others, much research has been dedicated to understanding the factors that influence a household's decision to adopt solar or not. Past research has shown that factors such as, pro-environmental attitudes, return-on-investment, incentive policies, and investment uncertainty are important drivers of this decision [1–3]. These studies use data that are aggregated across many households, and are thus unable to investigate the relationship between household energy use and solar adoption.

We hypothesize that households that have many 'white-ticket,' high-energy-consuming appliances, such as drying machines and electric vehicles, may be more likely to install PV. These households would be able to offset more of their energy consumption with in-home generation, and see increased return-on-investment relative to households with lower energy consumption; especially with appliances that can be turned on and off to shift loads to times of high solar production. In economic terms, we suggest that a PV installation can be thought of as a q-complement[ii] in utility to white-ticket appliances. This means that households with many white-ticket appliances would have more of a reason to install PV.

2. METHODS

To investigate our hypothesis that households may view larger energy-consuming appliances and

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[ii] See [4] for a definition of q-complementarity.

solar panels as complementary goods we build a statistical model that relates the probability of solar adoption to the appliances owned and the characteristics of a household. If our hypothesis is correct, we should see strong correlation between solar adoption and the ownership of white-ticket items.
Data for the analysis comes from a web survey of Upper Austrian households that was completed in 2017. This survey collected characteristics and appliance ownership information from 1,750 households.

3. PRELIMINARY RESULTS

We use a standard probit econometric model for the preliminary analysis. The model estimates the probability that a given household adopts PV, based on household characteristics and the appliances they own.
After accounting for household characteristics, we find some evidence for a complementarity between PV adoption and white ticket appliance ownership. Specifically, the results show that owning a sauna, swimming pool heater, and electric vehicle are associated with higher probabilities of solar adoption. These also represent the most energy-intensive household items. Interestingly, we do not find a significant correlation between solar adoption and the ownership of other white-ticket items such as electric washers and dryers.

4. CONCLUSIONS

This research investigates the reasons why some households adopt solar generators and others do not. While there has been much research on this topic, no study has addressed the possibility that households may purchase PV generators in part to complement other energy-intensive items they own or plan to purchase. We find some evidence that this type of complementarity may exist, as ownership of solar is correlated with owning electric vehicles, saunas, and swimming pool heaters.
These findings are a preliminary signal that households consider the dynamics of their energy usage when purchasing energy-relevant items. This suggests that policies and information campaigns that make clear how new items interact with existing household items may increase participation in the energy transition and uptake of new technologies.

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CONTEXTUAL THERMOGRAPHY: A NEW SOCIO-TECHNICAL METHOD FOR UNDERSTANDING ENERGY AND COMFORT?

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1. INTRODUCTION

We propose a new socio-technical research method for understanding thermal comfort research, namely 'contextual thermography'. The goal of contextual thermography is to provide a more valid and richer understanding of the socio-technical nature of termal comfort in homes. Contextual thermography combines, in one method, physical (temperature) data and social (routines, relations) and human/physiological (skin temperature, clo) data . Analysis of data from this approach is yet to be fully developed, but here we set out the rationale for developing this novel method and initial approaches being considered to analyse the data according to the 'socio-technical' approach set out by Love and Cooper [1].

2. APPROACH

Historically energy research into thermal comfort has focused on combining social research methods (self-report via closed question format) with separate point temperature measurements taken by a thermistor. Although mainstream buildings physics theories of thermal comfort have advance from the early days [2], even contemporary practice continues to use dual streams of data collection as set out above [3]. The standard approaches are problematic for two reasons: first, the frames of reference for subjective self-response and ambient temperature measurement are taken with distinct frames of reference [1]; two, neither approach captures necessary elements of spatio-temporal or social context, critical to understanding the socio-technical nature of thermal comfort. Here we explore a new method aimed at addressing these significant shortcomings.

A key method for deeper undstanding of social context is ethnography.This method serves as an important point of departure. How can physical temperature data be captured in a way consistent with ethnographic methods? Since temperature can be inferred from blackbody radiation captured via infra-red thermography, the natural step is to combine video ethnography with infra-red thermography. Normally, thermography is used in the context of energy, buildings and comfort in one of two ways: static images of buildings to establish 'cold spots' where there is thermal leakage, or in the use of skin temperature measurement used as a proxy for thermal comfort. Such uses reflect the tendency to treat the building and the occupants as independent entities. By combining both approaches such that entire rooms are captured by a thermal camera and multiple images are taken, spatio-temporal issues are addressed. Futher, it allows interpretations of practices being performed, within the wider social and technical/physical context and thermal information about the people.

Preliminary analysis of the thermographs is around relational information between actors and agents as well as differences in physical temperature values across them. Dynamic spatio-temporal 'thermal landscapes' can be captured as well as social and behavioural routine relevant to comfort practices. By using the same frame of reference we uncover if and how physical measurements correlate with social methods of temperature regulation.

3. RESULTS

The data can be subject to a range of analyses from entirely technical (e.g. taking averages temperature readings across regions of interest – the background, the people) entirely social (e.g. by observing and interpreting the routines, practices, meanings and relations holding between people and objects in the context) or in a socio-technical way, by understanding how patterns of thermal regions of interest interact with social practices or routines, identifying comfort practices indicating subjective sensations of being too hot or cold and so on. Such a method would involve combining quantitative readings across regions of interest in the thermal images with qualitative, interpretative analysis of the social, making it a true mixed method. Importantly, we recognise that to make the physical measurements of temperature more social in nature, a relational approach could be adopted, rather than an absolutist approaches normally adopted (i.e. absolutist positions identify particular room temperatures and attempt to associate those absolute temperatures with levels of comfort). Relativistic approaches (i.e. comparing the differences across the thermal context, exposed skin and clothed body areas) fit more closely with major social theories such as social practice or actor-network.

4. CONCLUSIONS

Contextual thermography is argued to be a novel socio-technical method to collect integrated physical and social data. This approach enables a genuinely even-handed interdisciplinarity between the social sceinces and building physics so essential for generating good evidence to support better, more effecitve energy policy [4].

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Assessing demand-side solutions for climate change mitigation

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Keywords: demand, service, social aspects, climate change mitigation, assessment, transition

1. INTRODUCTION

Assessments on climate change mitigation, such as those advanced by the IPCC, need to be revisited to understand how accelerated actions can be achieved in short term with long term stabilisation impacts. The limitation of the assessment are threefold. First, mitigation scenarios focus on the long-term evaluating pathways in 2050 or 2100 and emphasize primarily supply-side technology driven solutions. They insufficiently address short-term individual, community scale, societal scale actions and lack detail in representing demand-side behavioural options. Second, mitigation assessments are dominated by engineers, quantitative modellers, and economists, but insufficiently reflect other social sciences, such as psychology, sociology, and anthropology, all of which consider behavioural options. Third, the science of climate solutions lacks synthetic evidence that can be assessed efficiently. As a result, the IPCC has made little progress in understanding climate solutions adequately, i.e. what works well under what conditions. Addressing these shortcomings is a main community challenge for the social sciences, with potentially valuable contributions from the BEHAVE community.

2. STATE OF THE ART

Demand-side options for climate change mitigations are widely discussed in the literature, but only scarcely comprehensively assessed. A key contribution was made by the chapter on lifestyles, well-being and energy in the Global Energy Assessment [1]. The most recent assessment report by the Intergovernmental Panel on Climate Change (IPCC) emphasized in its key messages that low energy demand solutions are key precondition to achieve climate change mitigation while keeping other sustainability risks low [2]. The report did also point to many specific options and issues, but kept short of systematically summarizing behavioural and demand-side options for climate change mitigation. Our subsequent review then attempted to bring the demand-side solution together, and discuss crucial issues [3].

3. NORMATIVE AND METHODOLOGICAL CHALLENGES

A key challenge involves the evaluation of options. From an economics perspective, important dimensions of evaluations involve the costs and benefits for society. This is relatively straight forward if monetary terms are involved, and if the metric of evaluation is utility observed in revealed preferences. However, behavioural mitigation options require a change in behaviour, thus making revealed preferences a problematic perspective for evaluation. Even more, with changing social context and infrastructures, preferences change endogenously. For example, with ample space for cars, people may predominantly drive cars, whereas an expansion of bike lanes may result in increased uptake of cycling [4]. The result may be reduced GPD (less hospitalization due to obesity, reduced purchases of cars and fuel), but improved health and happiness. Such a result is difficult to include into aggregate mathematical models of optimal climate mitigation strategies (these models prefer supply-side technologies that are relatively straight forward to parameterize, and can be evaluated from the aggregated perspective of economic growth and financial costs). Hence, a comprehensive aggregate assessment of behavioural, social, lifestyle, and service approaches for climate change mitigation has to be explicit about normative choices, and has to find comparable meaningful metrics of well-being [3].

4. TOWARDS COMPREHENSIVE ASSESSMENTS OF DEMAND-SIDE SOLUTIONS

Social sciences have identified important categories and concepts relevant for climate change mitigation. These include insights on diverse set of behaviour from psychology, the importance of social practices from sociology, the role of sustainability consumption from consumer studies, empirical results on political feasibility from political sciences, the system-wide impact across producers and consumers from industrial ecology, and normative insights on well-being and sustainable development from economics, sustainability sciences, and philosophy. A main issue is that the literature is exponentially growing, making literature analysis challenging, and disparate, and sometimes more based on marginal novelty rather than on building a systematic knowledge base.

Systematic reviews are best suited to address this. With systematic reviews, knowledge will be aggregated comprehensively and in a transparent and reproducible manner, thus making it ready for assessments on climate change [5]. In a recent commentary, a range of researchers from different disciplines, including myself, attempted to sketch how different disciplines and perspectives could interact to produce a systematic assessment on demand-side solutions for climate change mitigation [6]. A number of contributions to the BEHAVE conference would be very valuable in contributing to this framework.

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USER IN CONTROL: PEOPLE-CENTRED APPROACH FOR DEVELOPING ICT SOLUTIONS AND SUPPORTING ENERGY EFFICIENCY IN BUILDINGS

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Keywords: ICT tools, behaviour change, user engagement, people-centred approach, energy efficiency, healthy lifestyle

1. INTRODUCTION

This paper presents a people-centred approach to increase awareness of building users, change their habits and practices, towards supporting energy efficiency and healthy lifestyles [1]. This work builds on top of the experiences gathered within the context of the H2020 MOBISTYLE project [2]. Extensive literature shows that building energy usage at home and work is correlated to behavioural patterns adopted by individuals during their public and private life [3]. Therefore, a better understanding of the social, psychological and physical drivers of consumer acceptance and behaviour change in relation to energy efficiency has been promoted by state-of-the art research [4]. It is within this interdisciplinary and innovative field of research, that this paper offers attractive ICT services for users. Final scope is the increase of understanding of how user-centred buildings technologies can support energy efficient and healthy lifestyles in buildings.

2. METHODOLOGY

In this perspective, this paper focuses on a methodology we adopted for the elaboration of an interdisciplinary questionnaire, studying the user awareness and possibilities for developing ICT-based engagement campaigns. The core concepts for the development of the questionnaire are drawn from the synthesis of the Theory of Planned Behaviour (TPB) and insights on social behaviours, such as the ones mentioned in the Theory of Practice (TP). The TPB is a psychology theory explaining that attitude toward behavior, subjective norms, and perceived behavioral control, together shape an individual's behavioral intentions and behaviours [5]. The TP, on the other hand, explains that behavior is an outcome of complex inter-relationships and shared social practice including the influence of the environment in which they occur [6, 7].
The questionnaire unifies the strengths of both theories and tries to overcomes the theories weaknesses, especially to establish a link between individual's and group behaviour. On this basis, a system architecture for the Behavioural Change Intervention Action Plan (BCIAP) has been developed (Figure 1) that includes a description of: (1) optimization purposes; (2) user-based actions; (3) monitored variables, related to energy use (indoor environment monitoring systems and smart meter data). The architecture takes into account users' motivations, attitudes, subjective norms and perceived behavioural control. Based on the information made available from the questionnaire responses, together with data coming from sensors, the BCIAP system architecture defines scenarios of behavioural change intervention implemented into the ICT tools.

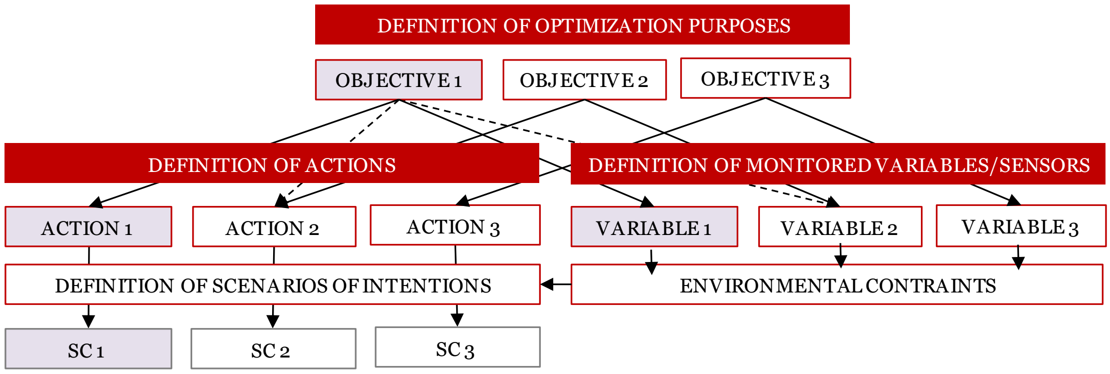

Figure 1. Structure of the Behavioural Change Intervention Action Plan, including optimization objectives, definition of actions and the data gathering from sensor, for the implementation of the scenarios of interventions

3. ICT SOLUTION DEVELOPMENT

Through the BCIAP methodology, the key factors that trigger people to change their behaviour can be defined. In addition, the methodology contributes to defining requirements for developing the ICT tools and intervention scenarios in order to provide user-friendly and attractive services. Through the questionnaire and other people-centred observations (focus groups, interviews, participant observation), it is possible to understand not only how and when people consume energy, but why do they actually do it. This additional layer of personal information opens opportunities to tailoring ICT solutions and inform users at the individual and collective levels.

4. DEMONSTRATION AND VALIDATION

The developed approach and tailor-made services are being validated in the framework of five demonstration cases: (1) social housing apartments in Aalborg, Denmark; (2) university buildings at the University of Ljubljana, Slovenia; (3) hotel apartments in Turin, Italy; (4) an office building in Kerkrade, the Netherlands; (5) residential houses as part of the Smart City Wroclaw, Poland. Particularities of these demonstration cases are gathered via the questionnaire for adapting the general ICT tool to different cases and their cultural specifics, age, gender, social and employment status, locations, and buildings. These specifics are identified by ethnographic approaches, including focus groups and interviews. Through combination of qualitative and quantitative people-centred approaches, ICT solution will be adapted to specific user needs and requirements.

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SMART DISTRIBUTED THERMAL STORAGE: CUSTOMER EXPERIENCES AND IMPLICATIONS FOR DEMAND RESPONSE BUSINESS MODELS

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Keywords: smart energy, distributed storage, heating controls, comfort, home automation

HOMES AS SITES FOR DEMAND RESPONSE

There is a growing need for electricity demand to be more flexible and the residential sector offers potential for load-shifting as well as demand reduction. A great deal of effort has been poured into home automation, yet fully-connected smart dwellings pose many technical difficulties and have sat uneasily with the complex nature of home life, where values, identities, activities and relationships all influence technology adoption and outcomes [1], [2]. But thermal loads are prime candidates for demand response, given their relative size, wide distribution and suitability for both manual and remote control [3]. Thermal storage in space- or water-heaters is much less expensive than electrical storage in batteries [4] although it is more limited in application, being available for heating only. Electric thermal storage heaters with night-time charging already contribute to heating in several European countries, providing a substantial proportion of their storage capacity, and there is scope to expand this by replacing or upgrading existing heaters. Using ICT to control this highly-distributed thermal storage around the clock, in order to match system needs more closely, seems a promising way of improving demand response capability, adding value to the storage for customers and for networks. But what is required for it to work effectively?

This paper draws on material from a three-year smart thermal storage demonstration project in three European countries, set up to test the assumption that ‘smartening' just two types of appliance – electric storage heaters and water heaters – could supply valuable demand response to electricity systems while maintaining or improving the energy service to customers. The appliances were connected with an aggregator through a gateway, with their users via digital controls, and with the supplier via interval meters.

A hypothesis underlying the ‘customer engagement’ research contribution to the project was that, in order to achieve worthwhile demand response, three conditions needed to be met: the technology would need to work well; customers would need to understand and be able to manage the controls; and they would need to have service expectations that were flexible enough to allow for demand response. The outcomes would be reached through a combination of human and physical/technical factors [5], as the product of three types of communication / engagement: between technologies, between humans, and between humans and technologies.

This hypothesis was broadly supported by the research, most of which was qualitative and involved interviews, surveys and focus groups with householders and project partners.. Analysis of customer experiences and of the processes and actors involved in rolling out, adopting and using the smart storage devices, showed how what at first appeared a straightforward exercise in ‘fit and forget’ technology roll-out turned out to involve many actors and interactions, sometimes in unpredictable ways. Demand-side management using a mix of controls operated by customers (for comfort) and aggregators (for system benefits) required careful preparation. Human actors included transmission service operators, district network operators, electricity retailers, third-party aggregators, salespeople, installers, housing managers, broadband suppliers, call centre advisors, designers and suppliers of a smartphone app to control the devices, and the householders themselves. Non-human ‘actors’ included storage heaters and hot-water cylinders, controls, online interfaces, broadband, gateways and supplementary heating devices. All actors were brought into the analysis, which included correlating the effectiveness of interactions with outcomes such as customer satisfaction, costs, and ability to operate controls in ways that supported demand-side management. The analysis led to a narrative of ‘five Cs’ that provided necessary conditions for demand response: comfort, control, cost, care and connectivity.

12. CONCLUSIONS

Residential demand response, even if partially automated, becomes effective through the consent, understanding and cooperation of householders, and through reliable interactions between technologies and people. These have to be worked for. Any business case for demand-side management needs to make provision for customer engagement through human contacts and user-friendly technologies. Recommendations for carrying out effective residential demand response programmes include making provision for feedback loops throughout the programme, trading some sophistication in the controls for usability by customers, training installers in communication skills and providing customer support as an integral part of a demand response service.

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ENABLE CONSUMERS TO LEARN ABOUT, ENGAGE WITH AND ADOPT RENEWABKE ENERGY TECHNOLOGIES: THE CLEAR PROJECT

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Keywords: Renewable energy, Behavioural changes, Engage consumers

1. INTRODUCTION

CLEAR [1] project is an European funded project under Intelligent Energy Europe program that started in 2014 and it ended in 2017. It had the objective to support consumers taking informed decision and purchasing renewable energy technologies and systems (RES) in five targeted European countries: Belgium, Portugal, Spain, Italy and The Netherlands. In many European countries the uptake of renewable energy technology by consumers was not up to expectations. Based on previous existing studies done by GFK [2] the population was divided in three main categories based on their behaviour; the Guarded, the Future Switchers and the New Consumers. Unfortunately, the previous research was not sufficient to understand in-depth purchase behaviour of consumers of those technologies. The consortium tackled the issue as follow:

- Ad-hoc surveys to better understand consumer behaviour
- The results were used to launch actions in each country to promote renewable energy technologies
- Iterations were done by launching more an in depth survey followed by other campaigns.

In total, three online surveys [3] were conducted using a computer assisted web interviewing (CAWI) methodology on online panels and took place in 2014 (n=5012), 2015 (n=5178) and 2016 (n=4673) in the targeted countries.

2. MAIN FINDINGS

The first survey brought up **three main obstacles** in engaging consumers in renewable energy technologies: knowledge of the technologies; price of the technologies/investment and the trust on the technology and installers. Through the usage of statements, treating a variety of aspects of RES, we have determined important drivers and barriers. Answers of different segments (positive or negative attitude towards RES) were analysed to determine which of the aspects, covered by statements, are the drivers and barriers in the consumers' decision-making process. Gap analysis showed consumers who nourish positive attitude towards environment and climate change are much more likely to recognise the **importance of lowering climate change** (+30%) through RES and believe in the **savings RES**

can make for them (+27%). The second and third surveys showed that**:**

- **Consumers need constant reassurance throughout the purchasing process.** Through Max diff analyses of the information needs within different stages of the purchase journey (thinkers, intenders and adopters) it is clear that, to gather the attention of consumers as to decide to invest, the financial return is key. It can be expressed in many different ways (ex ROI or in net profit per year, or along the lifetime of installation) but it has to be there and it has to be easy and comprehensible for consumers to relate with.
- While translating the survey result on the field (launching group purchases) it became immediately clear that the majority of consumer **needs personalisation.** As consumers progress on their purchase journey, information needs shift from general needs to product specific personal needs.
- **Facilitate the RES uptake by communicating the right message at the right time**. Further up the purchase process information should become more detailed and should take into consideration other paramount elements such as insurance, warranties, guarantees and after sales process and services.

Aside those common findings, each country has its own difficulties within the purchase journey. As a matter of example Portugal lacks direct liquidity and consumers has difficulties to get “small loans” for those investments. A common denominator is that the instability of the legal framework refrains the RES investments.

3. CONCLUSIONS

Thanks to the three surveys, the consortium has tackled the three main obstacles to the up taking of renewable energy technologies:

- Increasing consumer knowledge of the technologies thanks to an online decision making tool that has helped over 80.000 users, more than 20.000 individual dossiers treated and the launch of 5 renewable energy web communities with over 2 Million views per year.
- Increasing trust in the technologies and in the installers via 7 test programs and more than 800 direct communications and 100 references in other magazines.
- Decreasing the upfront investment barrier/lowering the price thanks to 26 group purchases that had manage to engage almost 100.000 consumers and lead to the purchase of almost 30.000 installations (photovoltaic, solar thermal, pellet stoves, heat pump for heating and cooling)

The political and Renewable energy policy instability creates worries and incertitude in consumers. H2020 funded project CLEAR 2.0 [4] that started in 2017 will focus on European and National advocacy to stabilise legal framework while maintaining its mission to engage consumers on RES. During Behave 2018 the purchase journey for RES will be presented including the main findings and group purchases and communication examples from CLEAR project.

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HOW TO BEST STIMULATE ELECTRIC VEHICLES' ADOPTION?

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Keywords: Mobility, Electric Vehicles, Behavioural Economics, Framing, Sustainability

1. INTRODUCTION

Progress in the development of green technologies is crucial to accelerate transition to more sustainable cities and regions. For instance, vehicles that are powered by electricity and have no internal-combustion engines might contribute to decrease CO_2 emissions from the transport sector [1]. However, in order to release their potential fully, electric vehicles (EVs) need to be purchased by consumers in large quantities. In this study, we propose and test behavioural strategies to enhance the intention to adopt EVs. In particular, we run an online experiment to test the effect of two information-framing strategies on the intention to adopt EVs. We find that making the cost savings related on the use of electric vehicles salient is an effective strategy to make individuals more willing to adopt EVs.

2. SALIENCE AND SOCIAL INFLUENCE

The choice to buy a pro-environment vehicle can be inhibited not only by material barriers, but also by cognitive ones [2]. These cognitive barriers prevent individuals from making choices that are good for themselves and the society [3]. In particular, individuals might fail to adopt EVs because they are prone to inertia and resist changes [4]. They might also be reluctant to adopt EVs because they tend to overvalue the high purchase price and undervalue the low lifecycle operating costs [5]. Small changes in the choice context might help attenuate such myopic tendency and resistance to change [6]. First, making EVs' low lifecycle operating costs salient might prove to be an effective strategy to help individuals appreciate the net benefits from purchasing an EV instead of a conventional one. Second, informing individuals that similar peers have chosen to purchase EVs, might be effective in fostering a motivation towards change [7]: the more individuals identify with the described peers, the more they are likely to follow the latter´s behaviour [8]. In this study, we test whether small interventions to the choice context of hypothetically purchasing a vehicle, enhance the intention to adopt EVs. In particular, we test i) whether making salient that EVs have higher cost savings than conventional vehicles, and ii) whether providing a descriptive norm about EVs, increases individuals' willingness to adopt EVs. This setup enables to understand how to communicate EV information so that individuals can overcome their cognitive biases and make better vehicle adoption decisions.

3. METHODOLOGY

To understand the effect of salience and social influence on the intention to adopt EVs, we designed an online survey experiment. We collected 591 completed responses using social media and newsletters. The recruitment was restricted to respondents living in South Tyrol, an autonomous region in the north of Italy which history made a special context to study the role of social influence. The experiment was designed in Opinio, and treatments were randomized in the survey redirect page. To measure intention to adopt EVs, respondents were presented a hypothetical purchase scenario between a conventional vehicle and an EV, and a cheap talk message was sent to reduce the hypothetical bias [9]. As experimental manipulations, we used figures informing about the price and technical characteristics of the two vehicles. For the salience treatment, the figures informed also about the vehicles lifecycle operating costs to highlight EV net benefits. For the social influence treatment, figures also informed about the increase in EVs' registrations made by South Tyroleans in the last decade to suggest a descriptive norm. We used a between-subject design, where each respondent is assigned to only one treatment. To further isolate the effect of our treatments on the intention to adopt EVs, we added a final survey about collective self-esteem perceptions [10], environmental attitudes [11], and economic preferences, such as time, risk, trust and reciprocity [12].

4. CONCLUSIONS

The results from the online survey experiment show that, compared to the baseline (51%), the "salience" treatment significantly increases the percentage of people willing to adopt an EV (59%). In particular, both non-parametric tests and regression analysis show that making EVs' net benefits salient is effective at making individuals willing to overcome the cognitive barrier represented by the high purchase price, and thus prefer EVs to conventional vehicles. Results also show that compared to the baseline, the "social influence" treatment slightly increases the percentage of people willing to adopt EVs (53%). However, this is not statistically significant. Besides being an autonomous region with unique cultural traits, South Tyrol is also characterized by three language groups (Italian, German, and Ladin). Therefore, this articulation into subgroups might decrease identification with South Tyroleans. The insignificant collective self-esteem item in the regression investigating EV adoption choice confirms this. This result suggests that, to be effective, a social influence strategy has to target the three language groups differently.

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EXPLORING EFFECTS OF ENTERTAINING COMMUNICATION STRATEGIES PROMOTING PRO-ENVIRONMENTAL BEHAVIOR

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Keywords: Pro-environmental communication, gamification, storytelling, involvement

1. INTRODUCTION

Persuasion techniques embedded in communication campaigns remain the most popular intervention strategy for promoting pro-environmental behavior [1]. Hence, social marketers, public and non-profit organizations use communication strategies to persuade citizens of the importance of environmental protection and to change their behavior accordingly. Most public communication campaigns are designed to provide people with more information. However, this strategy – referred to as the informational strategy – seems to result only in moderate effects [2,3]. This calls for a more detailed investigation into what communication strategies will result in more effective persuasion. Thus, the present study explores citizens' response to traditional informational as compared to more entertaining communication strategies such as gamification or storytelling.

2. BACKGROUND AND PROPOSITIONS

Explanations for the missing persuasion of informational communication strategies may draw on the dual-process models [4]: Departing from newer empirical evidence that pro-environmental issues cause only low involvement with most consumers we presume that consumers might not process the information conveyed through informational communication strategies, because the strategies demand for higher levels of involvement [1]. Hence, we suggest that more entertaining communication strategies will be more effective in persuading consumers in the context of pro-environmental behavior. These strategies aim at increasing consumers' involvement with a message in order to induce the necessary motivation to process the according information.

Gamification and storytelling have received growing attention from both academics and practitioners as a means of motivating user engagement [5][6]. Diverse research provides empirical support for the positive effects of more entertaining communication in the context of education, work, or even sustainability behavior focusing on learning or behavior change. However, so far only few studies have investigated citizens' response to gamification or storytelling in the context of pro-environmental communication. The present investigation addresses this shortcoming of past research by exploring citizens' perceptions of these types of entertaining communication in comparison with more traditional informational campaigns in the context of promoting green electricity.

3. EVIDENCE FROM AN EMPIRICAL STUDY

The study used a mixed-method approach to collect and analyze data from 30 consumers. A theoretical sampling strategy was employed [7], insuring the balanced inclusion of participants with regard of age, gender, and education. All participants were presented with three different types of communication (informational strategy, gamification and storytelling). Data collection for participants' response to the communication occurred through semi-structured in-depth interviews, in combination with closed questions.

Results reveal that participants were more inclined to engage with the gamification or the storytelling example as compared to the informational communication (a flyer), reporting stronger enjoyment, liking and entertainment. In similar vein, they reported lower levels of invested effort while attending to the entertaining types of communication. In contrast to the positive engagement, consumers perceived the gamification as well as the storytelling example to be less informative and to provide too little information in comparison to the flyer. Thus, the present study reveals a paradoxical effect of entertaining communication in the context of promoting green electricity: Entertaining communication leads to higher information processing motivation, and at the same time is denied a persuasive potential.

4. CONCLUSIONS

This study contributes to existing literature on communication effects, by exploring consumers' responses to gamification and storytelling in the context of pro-environmental communication. In this context, effects of entertaining communication seem to be more complex as compared to the context of behavior change, revealing a paradox between engagement motivation and perceived communication effects. Explanations for its paradoxical effect may draw from the heuristics and biases approach and more recent research that proposes that people under low-interest tend to use mental short-cuts [8]. Results suggest that individuals perceive the type of communication strategy (informative versus entertaining) as a heuristic cue, concluding that entertaining communication cannot be informative. Another explanation proposes that the engagement caused through gamification or storytelling raised consumers' level of involvement and therefore led to a higher need for information. As a result, the consumers' need for information could not be satisfied based on these examples. As an implication for practitioners, results from this research suggest using entertaining communication such as gamification or storytelling as a teaser to engage low-involvement audiences only in close combination with additional informational strategies.

However, quantitative research remains necessary to test the propositions derived from this exploratory study. Despite its limitations, conclusions drawn from this study contribute to an increased understanding of the effectiveness of communication strategies that incorporate more entertaining elements in sustainability communication.

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THE SIGNFICANCE OF ENERGY POVERTY AND LOW INCOME AS KEY BARRIERS TO THE ACHIEVEMENT OF HOUSEHOLD ENERGY AND EMISSIONS TARGETS IN GERMANY

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Keywords: energy poverty, investment decisions, actor behaviour, energy system, energy transition

1. INTRODUCTION

Consumers at the heart of the energy transition are key to unlocking the potential to achieve energy and climate change targets in Germany. Embedded in the European energy policy direction, it is becoming increasingly evident that without the active participation of households, the ambitious renewable energy and energy efficiency targets of the energy transition will remain unattainable. As such, households in Germany are responsible for a significant share of the final energy consumption (~43% including residential and personal transport) [1] and are expected to contribute by increasing shares of renewable energy use in heating (+14% by 2020), electricity (+≥35%) and transport (+10%), and decreasing energy consumption for heating (-20%), electricity (-10%) and transport (-10%) [2]. However, income plays a key role in influencing how some households are fully able to engage with and benefit from the changing energy system.

Estimates put 11-21% of the German population experiences energy poverty [3]. Energy poverty in Germany is a contentious issue as the national government position resolutely intends to address overall poverty rather than parts of poverty [4]. Despite this, the phenomenon is on the rise due to a combination of high energy bills (due to high energy prices, low income and poor energy efficiency [5]. Less than 45% of households have sufficient disposable income to afford the high upfront costs of investments in costly technologies such as building insulation, renewable energy and energy efficient heating systems, and electric cars, while only 15% of households in these upper income brackets are also homeowners [6].

What contributions can realistically be expected when just a minority of households have the available capital and are in the decision-making position as homeowners to invest in the required renewable and energy efficient technologies? What impact will the increasing focus on investments in decentralised renewable energy technologies have on households, especially lower income households? This research looks at completing the picture with a holistic energy system analysis that accounts for the heterogeneity of the population as actors and the limitations in investment arising from socio-economic constraints.

2. CASE FOR A DISAGGREGATED ASSESSMENT

Current policy is based on modelling assessments which assume a homogenous population and monitoring benchmarks are calculated for average households. This method underestimates the impact on lower income households and overestimates the possible contributions from this sector towards achieving the overall objectives of the energy transition. Income is a key point of departure to better assess how households will invest in technologies and spend on energy costs. While on average, households spend 10% of their expenditure on direct energy costs (operating costs of e.g., home and transport fuels) and there is a distinct variation in the investment in technologies: as income increases, so does the indirect energy expenditure (e.g., investment in appliances, home improvements). Disaggregation of the household sector shows that only 24% of households in the upper income brackets are also homeowners and therewith in the position to make and afford the high upfront costs of major renovations or renewable energy or energy efficiency technologies. Space heating and transportation needs, which represent the largest shares for energy consumption, also vary greatly depending on income and require a differentiated analysis. On average 77% of households own at least one vehicle, of which about 50% are purchased used, and represent more than one-third of the energy consumed by households [6]. This wide variation in ownership, consumption patterns and investment decision-making ability should be incorporated into the energy planning process so as to better enable setting achievable targets.

3. ENERGY MODELLING METHODOLOGY AND SCENARIO ANALYSIS

The analysis includes the adaptation of the TIMES-Germany model by including a disaggregated representation of households into heterogeneous groups based on socio-economic characteristics. The assessment includes both residential and personal transportation energy demand to comprehensively describe the impact on the total household energy. The model will account for budget constraints and investment decision making profiles in a two-step process (investment + operation) through a mix of capacity constraints and discount rates. This will better account for the gaps in investment from the different income groups and, in turn, assist in identifying insights for achievable targets and development of policy measures towards the improvement of the energy welfare of lower income households is explored.

4. CONCLUSIONS

The value of the adapted modelling methodology will be validated and provide the identification of measures that can form a differentiated policy response and target benefits to all sectors of society - effectively unlocking the desired active participation in the energy transition. This research shows:

- Improved representation of households providing income group specific insights into expected contribution towards targets
- The majority of households (have insufficient funds or do not have the decision-making power to invest in energy efficient and renewable upgrades and technologies (i.e., not homeowners)
- Increased recognition of and accounting of energy poverty in a holistic energy system analysis towards an integrated policy response
- Exploring the significance of energy poverty and low income as a barrier to achieving the objectives of the energy transition

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HOURLY UTILISATION AND ENERGY CONSUMPTION OF A FINNISH OFFICE BUILDING

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Keywords: user behaviour; occupancy measurement, energy efficiency;

1. INTRODUCTION

Office buildings are only partially occupied during opening hours and the British Council for Offices reports that that occupancy levels are typically between 60-70% during the core office working hours [1]. This means that on average in office buildings 30-40% of the desks are empty during the core working hours. Labeodan et al. [2], explain that a substantial number of commercial buildings still use assumed occupancy profiles and schedules "*with little or no consideration at all of the energy implications and savings accruable at periods when spaces are partially occupied or unused*". The same authors have also extensively described the various ways to dynamically measure occupancy and this includes systems that measure CO2 concentrations, that use camera images or that study energy consumption patterns [2]. We have used cameras and people counting software to collect occupancy data in office building in Helsinki. Occupancy data is for buildings in very valuable and difficult to obtain. Occupancy data has been collected in an office building in order to examine if the observed occupancy profile is different from to the occupancy profile which is assumed by the schedules of the building management system. The building management system schedule is configured based on the assumption that the building operates 7 days a week from 06:00–22:00. The data enables the influence of the occupancy patterns on the energy consumption to be analysed. One target is to examine the amount of energy that is wasted by the building being conditioned while it is almost empty in the last few hours of the work day.

2. METHOD

The research setting is an office building in Helsinki, Finland. The building has a net floor area of approximately 7,000 m2 and the data has been collected for a 7 month period from the beginning February 2017 to the end of August 2017. During this period, a people counting system was installed at each the four exists on one floor of this building so that the occupancy of the floor could be accurately measured. The people counting system for each exit consisted of a camera and a software programme that processed the video images. The study also utilised the existing energy consumption measurement system of the building. The data that has been collected on the number of occupants and energy consumption have been grouped into three categories which are the average work day, the average summer work day and the average weekend day. The average work day is calculated using data from all of the weekdays except for July, the average summer work day is calculated using data from all of the weekdays in the month of July and the average weekend day is calculated using data from all of the weekend days during the 7 month period.

3. RESULTS

The clearest insights come from comparing the summer work day with that the average weekend day:

- The daily occupied person hours of the average summer day is only 48.7% of that of the average work day.
- The daily occupied person hours of the average summer day is less than 1% of that of the average work day.
- In July the energy consumption per occupied hours is 2.12 kWh/person hours per day which is 160% of that of a normal working day.

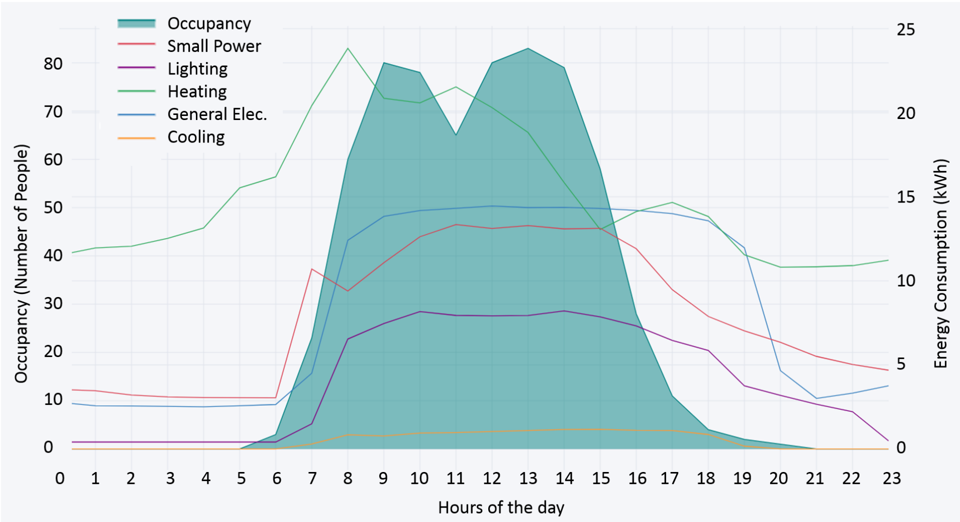

Figure 1. Number of occupants and energy consumption for the average work day.

4. CONCLUSIONS

It is difficult to accurately measure occupancy at any one time in the life-cycle of an office building. This research has studied occupancy for a period of time and some of the findings are as follows:

- The opening hours of 06:00-22:00 have been decided upon without really knowing the occupancy patterns.
- The people counting data gives a helpful insight into energy efficiency calculations and supports decisions related to workplace management strategies.
- The building is extremely underutilised during large portions of the year and there is a cost and an environmental impact related to this.
- Strategies that reduce energy consumption in these times or ways to increase utilisation in these times would add value to building owners.

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ANALYZING MULTILINGUAL ENERGY DISCOURSES IN SWITZERLAND

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Keywords: applied linguistics, discourse analyses, multilingual, corpus, Energy Strategy 2050

1. Energy discourses and multilingualism

In our international and globally networked working world, we are directly and indirectly exposed to texts from various sources, agencies, and media—especially in a multilingual country like Switzerland —in various languages. These texts form the basis of our knowledge and have a formative influence on decision-making, for example with respect to energy policies and consumer choices. In linguistic research, we analyze these texts as parts of discourses and show how intertextual patterns may have determined agency-based views. This helps us to understand how the debate on the 'Energy Strategy 2050' works and how inter-agency communication on this topic can be improved. In multilingual Switzerland, discourse about energy takes place in three different languages that enjoy equal official status as well as in Romansch (primarily spoken in Grisons) and in the lingua franca English. In my talk, I will focus on differences in linguistic patterns between languages that have been identified in the ZHAW research project "Energy discourses in Switzerland" (supported by the Swiss Federal Office of Energy under the Energy-Economy-Society program).

2. Multilingual energy discourses

I will present research questions related to multilingual Swiss energy discourses (2.1), problems and solutions (2.2) as well as initial results (2.3) of multilingual discourse analysis based on a large text corpus.

2.1 Research questions

Most linguistic discourse research has had a monolingual focus: texts from a single language are analyzed and discussed in one language (usually the same language as the language of the texts) [1]. The best-known handbooks and dictionaries in the field have no entries for comparative or contrastive discourse analyzes [2], [3]. However, initial methodological considerations on multilingual analyzes have begun [4] and, in the last ten years, the first empirical studies have appeared [5], [6], [7]. Based on this still relatively modest state of research, specific research questions of multilingual discourse linguistics have been developed for the project that is the focus of this presentation. For example, how are concepts of 'energy' realized in different languages? Are there gaps or voids in texts that are filled in other languages (e.g. references to arguments such as 'France still has also nuclear power')?

1.2. Problems and solutions

The first problem is the selection of a working language for the research team because language can influence the analysis process and therefore the results [8]. Triangulation as a qualitative methodology helps to mitigate this language bias. This is particularly important because German is not only a dominant working language in Switzerland, but also predominant in the texts of the corpus that the project is drawing on. It is important to prevent the German-language discourse patterns from being transferred to texts in other languages [6], [7]. The second problem is related to comparison as a method: From a linguistic perspective, a tertium comparationis is not a linguistic term or expression because that would be too closely linked to a particular language. Instead, it should be located as a pattern at a middle level of abstraction such as topos (a figure of thought that seems plausible), argument, voice, and speech act.

1.3. Results of the presentation

The following results will be presented: (1) agency-related patterns, e.g., quotations of dominant organizations in and between German, French, and Italian texts (‚who cited whom?'); (2) knowledge-related patterns, e.g., frame-semantic patterns of apposition (‚where is Vattenfall called an ‚energy giant'?'); (3) action-related patterns, e.g., differences in the frequency of COMPARING in texts of different languages ('Is Fukushima like/unlike Chernobyl?').

2. Conclusion and outlook

Energy is a not a national policy, but a global one. To understand how agents take part in this it is necessary to analyze multilingual discourses. Agents of discourses, which to date have no references to similar discourses in other languages, are given the opportunity to react to the similarities and differences through the research results. In order to achieve this, desiderata must be worked on [9].

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SIMULATING TECHNOLOGICAL INNOVATION MICRO PROCESSES – TOWARDS EXPERIENCE-BASED ROBUST POLICY RECOMMENDATIONS

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Keywords: Robust Decisions, Simulation, Knowledge flows, Innovation networks, Technological innovation, Experience-based expert group

1. INTRODUCTION

The proposed contribution provides insight into the process of system analysis carried out in order to provide robust recommendations on policy measures to improve innovation activities for the development of key technologies. The analysis focusses on empirically based simulation of communication, cooperation and knowledge generation and exchange between actors in the field which are not considered in conventional "energy system analyses". The analyses are designed in a way that maximal robust policy recommendations can be derived. Starting from requirements for robust policy recommendations in the context of energy system analyses (Droste-Franke et al. 2015) the designed approach for the analysis of technological innovation followed in the InnoSEn project is discussed before some first results are presented.

2. METHODOLOGY

2.1. Requirements for robust policy recommendations

In order to sketch the basic requirements for energy system analyses for deriving recommendations on robust solutions, first the specific challenges and needs for robust energy system analyses are discussed based upon findings of Droste-Franke et al. (2015) [1]. In order to reach dynamically stable and socially robust solutions for the design of energy systems and their framework conditions, epistemically and socially robust policy advice is required, ideally considering all options of action, framework conditions, and impacts. As one prerequisite to derive fitting, applicable and robust recommendations for the respective problem contexts, besides scientific expertise a broad set of technical professional and local experience-based knowledge is needed. Requirements like transparency and transdisciplinary set-up are discussed, before instruments developed at the EA such as the EA lab and the EA lab workflow as well as the instrument of inter- and trans-disciplinary expert workshops and groups are briefly introduced [2],[3],[4].

2.2. Project design, approach and empirical analyses as basis for robust simulations

In the second part of the contribution the specific approach followed in the project "Network Analysis and Simulation of Innovation Dynamics for new Key Technologies in the Energy Sector" (InnoSEn), funded by the German Federal Ministry for Economic Affairs and Energy (BMWi) is discussed. Starting with the overall project structure, reflecting the EA lab workflow approach individual elements for expert involvement are presented together with a mixed-methods approach for surveys and data analyses [5]. As a central element, the theory of Technological Innovation Systems is consulted to structure important barriers and potential measures according to key functions of the innovation system [6],[7],[8],[9],[10]. From these analyses questions to the adapted and applied agent-based model Simulating Knowledge Dynamics in Innovation Networks (SKIN) model [11] are deduced which provide a first orientation for the basic model design. In a next step, characteristics of actors and their environment are analysed on the basis of means of empirical research like interviews and data research and analysis in order to further calibrate and validate the model with respect to the real situation. In a final step, model experiments are performed which are derived from the questions provided by the analysis of the innovation system. In an additional loop the questions are further sharpened and analyses are adjusted and repeated where required, before final results will be available.

3. RESULTS

As first example results in the project which represent parts of the basis for model design, the questions posed to the model and first results of network analyses showing cooperation of important actors of the lithium battery innovation system which are applicable for calibration are shown.

4. CONCLUSIONS

Concluding, within the project an approach relying on mutual interaction of empirical analysis and modelling has been developed and to a certain extent realised, using the technology of lithium batteries as example. Various empirical methods have been closely linked to the model development and set up process, in order to design an instrument to derive epistemically and, to a certain extent, socially robust results for the analysis of innovation processes in the technology field of focus. The contribution, thus, shows exemplarily for the analysis of innovation processes ways to consider insights not only from empirical data and surveys, but also knowledge from directly involved experts and stakeholders in a model building process to design tools for robust system analyses as basis for policy recommendations towards dynamically stable and socially robust solutions.

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MODELLING BEHAVIOUR - BEHAVIOURAL MODELS: HOW TO INTEGRATE HUMAN BEHAVIOUR INTO ENERGY MODELS?

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Keywords: Energy Models, Behaviour, Zurich, Concept

1. INTRODUCTION

In the past, modelling the energy system was mainly based on cost factors and expected lines of technological development assuming rational users and decision-makers. In parallel, a growing stream of literature has looked into individual behaviour and social structures in the energy system. This research emphasizes that using energy takes place within a socio-technical system where individual decision-making and behaviour are influenced by factors that challenge the basic assumption of (purely) cost-optimising actors. These factors include limited time and knowledge, (conflicting) interests and motives of the various individual and collective actors as well as path dependencies, e.g. caused by established institutions, infrastructures or technological lock-in situations. More recently, efforts to combine those different streams of research in order to manage the complex transition to a more sustainable energy system have increased. Against this background, we propose a special session for this year's Behave conference, which focuses on the challenge to combine energy modelling with behavioural perspectives and have assembled a team of potential contributors from various disciplines.

2. GENERAL SPECIFICATIONS

This special session comprises respective studies in the fields of generation and diffusion of innovations to trigger a comprehensive discussion of the energy system that will contribute to answer the following overarching questions:

1. In which ways can energy models and behavioural perspectives be combined? To what extent are different energy models able to include input from empirical social science studies? Which input can be provided by different empirical methodological approaches in the field of social science?
2. What difficulties do researchers encounter when they try to combine energy models and behavioural perspectives? What approaches have been implemented successfully?
3. Are there peculiarities regarding different sectors (e.g. industry, households) or technologies (e.g. dwelling insulation vs. electric vehicle adoption), different aspects of energy related behaviours (e.g. individual vs. social acceptance) or research domains (e.g. generation vs. diffusion of energy innovations)?
4. What are the practical merits of combining energy models and behavioural perspectives regarding the development of energy related policies and interventions? How to maximise such merits in future efforts to combine energy models and behavioural perspectives?

To achieve this we combine presentations from studies and projects which take a variety of approaches and are in different stages of development. While some of them focus on the conceptual outline, others report findings from modelling or empirical work.

3. CONTRIBUTING AUTHORS

- *Joachim Schleich, Corinne Faure*, Xavier Gassmann, Thomas Meissner* An empirical study of the factors underlying the implicit discount rate: Findings from representative surveys in eight EU countries
- *Bert Droste-Franke, Gabriele Fohr* Simulating technological innovation micro processes - towards experience-based robust policy recommendations
- *Charlotte Senkpiel, Sandra Wassermann, Jessica Berneiser und Christian Hofmaier* Concept on modelling the adoption of energy related technologies on the basis of investment decisions of private households and organizations in the energy industry
- *Joachim Globisch, Matthias Kühnbach, Elisabeth Dütschke, Anke Eßer* Evaluating Identifying and Modelling Target Groups for Demand Side Management via Flexible Heat Pumps
- *Katrin Arning, Barbara Zaunbrecher, & Martina Ziefle*: Understanding energy efficient refurbishment decisions. A process model from the house owner's perspective
- *Emile Chappin* Agent-based model of energy efficiency technology adoption in households - a first version with policies targeted at intermediaries
- *Wander Jaga* (if possible as additional virtual presentation): Simulating behavioural change: a dynamical social psychological perspective

A new Smart Meter Research Portal

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Keywords: smart meters, demand response, big data

Abstract

Background

The Smart Metering Implementation Programme (SMIP) aims to install approximately 53 million smart electric and gas meters in around 27 million domestic properties in Great Britain by 2020. Smart meters provide high resolution (e.g. half-hourly) electricity and gas consumption data that has never previously existed on a national scale.

In order to leverage the investment in the SMIP and provide tangible benefit to the research community, the Engineering and Physical Sciences Research Council (EPSRC) have provided a £6m grant for a 5-year, multi-partner project to develop a Smart Meter Research Portal (SMRP) to provide vital access to energy data for UK researchers.

SMRP Vision

Our vision is to deliver a world leading multi/inter-disciplinary research programme, facilitated by a smart meter data portal. The portal will transform GB energy research through the long-term provision of high quality, high-resolution energy data that will support the development of a reliable evidence base for intervention, observational and longitudinal studies across the socio-technical spectrum.

The goals of **the portal** are to provide:

- A consistent, trusted, and sustainable channel for researchers to access large-scale, high-resolution energy data, thereby providing a reliable empirical dataset for research;
- An effective mechanism for collecting energy data alongside other variables from national surveys (e.g. English Housing Survey) or individual research projects;
- A confidential, ongoing repository of smart meter data enhanced with contextual dwelling, household and neighbourhood attributes for use in secondary data analysis;
- An Energy Advice Service for participants who want their smart meter data to be used for this purpose.

The ambition of the **research programme** is to undertake research that will:

- Support government policy;

- Kick-start the development of new products, services and energy markets;
- Help provide solutions to the energy trilemma (security, affordability and environmental sustainability);
- Facilitate better research by developing best practice guidelines and methods to improve data security and enable innovative uses of smart meter data.

Conclusion

Smart meters have the potential to facilitate the transition of energy systems to low carbon, distributed systems with consumers as active, rather than passive, participants. A key enabler will be improved linking of energy data with data from other sources (e.g. administrative, survey, smart grid, Internet of Things). SMRP will enable innovative research to support the development of these new services, including:

- Evaluation of new tariff structures to assess the differential impact across consumer segments.
- Impact of smart energy systems on the health, well-being and comfort of occupants.
- Identification, targeting and mitigation of fuel poverty.
- Optimising Demand Side Response.
- Disaggregating energy consumption using smart meter data
- Understanding the impacts of smart home technologies such as Home Energy Management Systems or smart heating controls on energy consumers
- Analysis of the impact of switching suppliers/tariffs on bills and energy consumption.

This paper will discuss the benefits, challenges and methods in developing a national data resource that aims to support a wide range of research across the energy sector. For example:

- Benefits to consumers e.g. through the provision of tailored, data-driven energy advice enabled by the use of smart meter data.
- Benefits to government, industry and charities/NGOs
- Data governance, data privacy and informed consent
- Data quality and uncertainties in data
- SMRP use cases
- SMRP research strategy and design

NUDGE: COMPLEMENT OR A SUBSTITUTE OF TRADITIONAL ENERGY POLICY INSTRUMENTS?

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Keywords: policy mix, nudge, energy consumption, online experiment

Despite the personal disutility that might result from undertaking energy-saving behaviours, proper compensation can be effective at boosting individuals' willingness to reduce their own energy consumption [1]. Traditional approaches consider compensation schemes based on economic incentives the most effective. As a consequence, energy policy mixes have mainly relied on this kind of tools, like market-based instruments and financial incentives. Nevertheless, there is overarching evidence that individuals' decision-making is affected by a more complex set of elements, that goes beyond financial considerations. Therefore, major benefits are likely to be achieved from the integration of traditional instruments with alternative ones, like nudges [2]. However, so far limited work has examined the interplay of nudges and standard policy levers in the energy and environmental contexts.

The current work aims to experimentally assess the effectiveness of an energy policy mix based on the integration of a traditional intervention and a nudge, by mean of an online experiment. The experiment will be launched on the online platform Prolific Academy this summer. The design is between-subjects, with 2x2 experimental conditions: "nudge", "traditional", "nudge and traditional", and control. The experimental setting draws from previous research [3]; nevertheless, the current study seeks to simulate the main elements of the decision-making process that individuals experience in their daily energy-saving choices. This is achieved with two design features: first, during the experiment, participants have to sustain a cost in terms of time and effort if they want to reduce their consumption; second, participants' payment is proportional to their energy saving.

To reproduce energy consumption in the experimental setting, participants are asked to mimic the wash of a load by interacting with the control panel of a simulated washing machine. Further, they are provided with the manual instruction of the machine, where it is reported how to use the panel and which washing parameters to select based on load characteristics. In order to simulate the real effort required to reduce energy consumption, the experiment is divided in two phases. In phase 1, the usage of the washing machine and the manual instruction are relatively simple. The goal of this phase is to make participants familiarize with the control panel; to incentivize participants to learn how to use it, they are charged with a penalty if they do not use it as reported in the manual instruction. At this phase, no energy saving is possible. In phase 2, participants can still use the washing machine in its basic mode, without any energy saving associated; nonetheless, they can use it in an advanced way too. The advanced usage of the washing machine, as well as the related manual instruction are more complex and envisage more washing parameters, that, if combined in the correct way, allow to reduce energy consumption. The personal effort that participants have to provide consists in reading the manual instruction of this phase to understand how to reduce their consumption. All participants go through both phase 1 and phase 2; the random assignment to an experimental condition takes place between the two phases. Those assigned to the "nudge" treatment are provided with a reference goal of how much energy to save; they also receive a feedback on how they are performing compared to their goal. The "traditional" intervention simulates a tax rebate, with a discount on the energy bill if a certain saving is reached. The "nudge and traditional" condition represents the innovative policy mix, and is based on the integration of the two treatments. In phase 2, participants are paid according to their energy saving level. The study aims to investigate how the different policies affect participants' effort to reduce their energy consumption; hence, the main dependent variable is the energy saving achieved in phase 2.

Given the different motivational levers underpinning nudges and traditional policies, it is foreseen that their integration will lead to positive synergies; this means that the impact of the two instruments, when combined in one policy mix, will be higher than the sum of their individual effects. Nonetheless this might not be the case, and interactions could be either non-significant or negative. The former situation might be caused by the substantial greater impact that traditional interventions have compared to nudges [4]; hence, there might be no benefits by integrating the latter in traditional policy mixes. Instead, the traditional interventions' reliance on extrinsic motivation might crowd out the motivation to save energy provided by nudges [5], leading to a possible negative interaction among the two.

To conclude, the goal of the current work is to provide preliminary evidence about the impact of an innovative energy policy mix. Further, the experimental design could open up opportunities for future developments: the same setting can be replicated to investigate the interactions of other policy tools beyond those considered in this study, in order to test different policy mixes, and eventually identify which are worth to be assessed in the field as well.

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ASSESSING AGGRESSIVE DRIVING EFFECTS ON POLLUTANT EMISSIONS AND ENERGY CONSUMPTION: CITY LEVEL ANALYSIS

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Keywords: Driving behavior; Energy consumption; Pollutants emissions; Real world data; Economic analysis; City scale

1. INTRODUCTION

Fuel consumption and pollutant emission rates are a function of the vehicle use (journey type, frequency, etc.) and its operating conditions (speed, accelerations, temperature conditions, etc.) and depend on both traffic conditions and driving behavior [1, 2]. Thus, a realistic assessment of emissions cannot be carried out without taking into account real-world operating conditions of the vehicles [1]. In this sense, the aim of this work is to assess the impacts of aggressive driving behavior on pollutant emissions and energy consumption at a city level. Furthermore, an economic analysis was performed considering the potential avoided emissions and fuel savings.

2. METHODS AND DATA

Figure 1 presents a generic overview of the methodological approach. Firstly, data was collected through two distinct methods: Sample A) using a set of on-board data loggers (a sample of 47 drivers was monitored for a period of at least six months in the Metropolitan Area of Lisbon) and Sample B) using a Portable Emission Measurement System (PEMS) (two drivers were monitored in the same route in the Metropolitan Area of Lisbon, driving normally and driving aggressively). Data from the i2D device (Sample A) was combined with street characterization data (such as hierarchical street level and traffic volumes) allowing building an integrated database with 28.9 million seconds of driving data. This extensive database was used to characterize in detail the city in terms of vehicle dynamics (by using the Vehicle Specific Power – VSP – methodology) and to obtain the percentage of time spent in aggressive driving behavior (aggressive driving was defined on a second by second basis considering acceleration thresholds per speed). Furthermore, PEMS measurements (Sample B) provided data on energy consumption and pollutants emissions for both aggressive and non-aggressive driving behaviors. Using the VSP methodology, the information obtained from the i2D and the data from the PEMS were combined in order to obtain a characterization of the energy and environmental impacts of aggressive driving behavior at a street level basis. Additionally, an economic analysis was made based on the valuation of emissions external costs and avoided energy consumption.

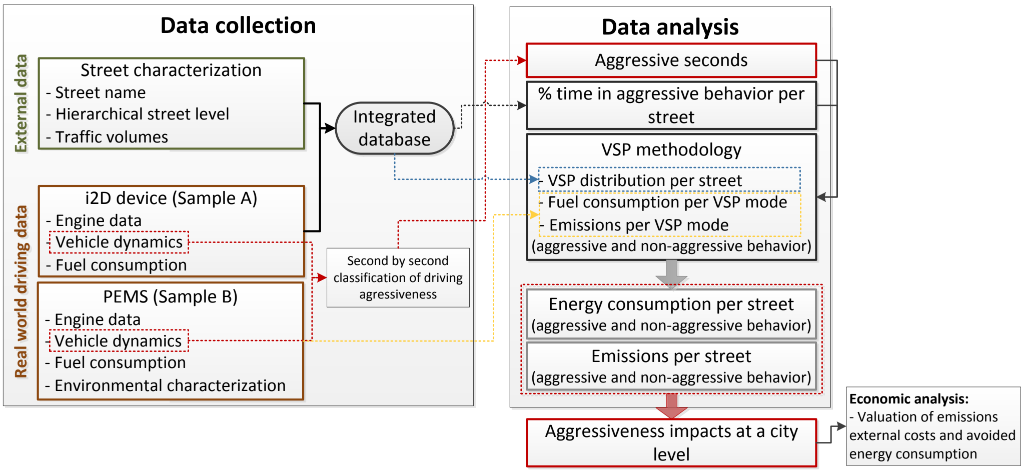

Figure 1. Generic overview of the methodological approach

3. RESULTS AND CONCLUSIONS

Results on energy consumption and emissions provided evidence that aggressive driving behaviors lead to increased energy consumption and emissions (CO, HC, NO_x, NO, NO_2 and CO_2). More specifically, energy consumption was found to increase by more than 200% for aggressive driving behavior, both for diesel and gasoline vehicles. Moreover, also an increase on pollutants emissions was found with this increase being higher (in percentage) for gasoline vehicles than for diesel vehicles. Considering the impacts at a city level, results showed that the impact of aggressive driving increases from level 1 to level 4 streets. The most local streets (level 4) present an increase on energy consumption of 16 percent points considering diesel vehicles and of 13 percent points for gasoline vehicles, comparing with level 1 streets (arterial streets). The same trend was observed for pollutants emissions.

The potential energy and environmental gains associated to aggressive driving behavior were also estimated. If these hard acceleration/braking events are avoided savings of up to 35 thousand euros (considering HC, NO_x and CO_2 external costs and potential fuel savings) may be achieved on a daily basis at a city level. This analysis evidences the impacts of aggressive driving behavior, providing a valuation of these impacts at a city level. Considering this, one may conclude that the implementation of policy measures promoting the decrease of aggressive driving events can offer significant savings contributing to achieve a cleaner and healthier urban environment.

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Beyond Energy Reports - A Use Case Summary for Energy Tips

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Keywords: Energy tips, Energy efficiency, Segmentation

1. INTRODUCTION

While the provision of energy saving information in the form of "tips" is not considered sufficient to change behaviour [1-3], it's found in many common types of utility behavioural change program including home energy audits, home and business energy reports, energy savings kits, and marketing materials. However, within most organizations, there is no centralized source for these tips, making it hard to determine the "best" behaviours, to target most likely audiences, or to frame the most compelling messages.

This paper discusses an effort to centralize energy savings tips for one utility and focuses on: (1) identifying where and when tips are currently used, (2) use cases for future application, and (3) implications for developing a customisable database of tips. We consider how this influences attributes used to characterise energy saving behaviours such that tips can be filtered according to programme goal (e.g. efficiency, demand shifting), target audience, and determinants of behaviour.

2. BACKGROUND

The provision of energy information to consumers is a strategy to support end users in energy reduction efforts, based on the premise that customers lack knowledge to determine which activities to engage in to deliver energy savings [4-6]. However, provision of tips does not always lead to savings, particularly when accompanied by information related to monetary savings [3]. Further, tip effectiveness appears to differ according to both the information that is provided to users, and the context in which that information is communicated.

Given these insights, and the prevalent use of energy savings tips across utility program, it seems clear that better understanding the use cases for tips (i.e. how tips are used, the audience segments they target, and which behaviours they hope to shift) could inform a more nuanced approach to designing and delivering energy savings information to customers to ultimately deliver better results. Further, utilising use cases to develop a centralised library of energy savings tips could support organisations provide a more coherent engagement with customers through using the same tips across programs, keeping consistency in tone and voice, and identifying where different programs are supporting same things and can reinforce one another. The current study therefore focuses on the first stage in this process: identifying the use cases for energy savings tips.

3. CURRENT STUDY

Pacific Gas and Electric Company (PG&E) has a database of 167 energy saving tips designed for use within the Oracle Home Energy Report (HER) program. There is interest in utilising tips across the PG&E portfolio, expanding the customer base receiving these tips. This presents an opportunity to customise tip content and target behaviours for specific audiences, and to optimise tip design for maximum impact through testing of specific message frames, strategies, and delivery channels.

We evaluated the current tip library and engaged stakeholders within the utility to provide input on current and potential use cases across the program portfolio. We utilized several methods to explore how to most effectively enhance the tip library this in the organization:

- Review of current use cases;
- Compilation of additional tips (identified deltas from existing list of tips);
- Semi-structured interviews with program, product, strategy and marketing stakeholders.

We then summarized and presented findings back to the identified stakeholders to ensure alignment.

4. RESULTS

The idea of comprehensive, searchable/customizable database was met with enthusiasm. We identified a wide variety of uses for tips across the utility and interest in a centralized tip library, including Home Energy Reports, Online Energy Check-Up, Time of Use rate plan, website and other marketing materials, low-income audits, community events and school programs. When we asked stakeholders about how they currently find and create tips, we learned that they use a small repertoire of tips and lacked a resource for developing new and customized tip options. There was a resounding interest in a centralized library if it could meet their needs. We also identified several use cases for tip queries and searches including specific times of year or climate zones as well as for specific customers (e.g. low-income, electric vehicles owners).

6. CONCLUSIONS

Our work identifies a clear need for a centralized library of energy savings tips. In addition, the use cases identified define a pathway to support the targeted delivery of tips. Some use cases require focus on audience segments, others on specific behaviours. This has implications on additional behaviour that may need to be added to the library, as well as the attributes through which those behaviours are described and defined such that they can be filtered or sorted to enable appropriate targeting of information and ultimately support customers in energy savings goals.

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Can new ICT tools trigger more Energy Efficient behaviours? Challenges and good practice to improve pilot design and implementation

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Keywords: Energy efficiency, Consumer behaviour, European Commission, H2020, Research and Innovation, Pilot concept design and implementation.

At the end of November 2016, the European Commission launched the Clean Energy for All Europeans package, which represents a large set of legislative proposals related to European energy policy. In this new policy context, consumers are placed at the centre of the energy system as drivers of the energy transition. However, a precondition for consumers to become active is their awareness of their own potential to permanently or temporarily reduce energy consumption. The fact that there is an untapped potential for energy savings that could be harnessed by changing energy habits and behaviour inside buildings is widely accepted. Yet, the human dimension of energy use in buildings is often insufficiently considered, and behavioural triggers are not well understood. In this context, ICT tools can help consumers better understand their energy use and manage their energy consumption while achieving significant energy and economic savings, without compromising comfort.

In order to support the development of these tools, the European Commission, through its research and innovation programmes, has devoted significant resources to support the development of innovative ICT technologies and solutions for Energy Efficiency. In fact, by May 2017, at least 42 projects that included tasks related to research, innovation and market uptake of smart buildings had been funded under Horizon2020 with an overall EU grant contribution of 259.7 M€ [1]. Since 2014, 17 projects have focused on the development of new ICT tools that enabled users to interact with buildings and adopt more energy efficient behaviours (receiving around 38 M€ funding) [2].

Past and ongoing projects have produced some significant results. For example, some ICT tools developed by these projects have managed to trigger up to 17% energy savings in real-life small scale pilots [3]. However, most projects have experienced important difficulties implementing demonstration pilots with effective ICT behavioural interventions. Thus, we believe it is crucial to take stock of the successes but also to analyse the obstacles faced by these types of projects. By doing so, this paper intends to support pilot design and implementation practices in behavioural interventions in the field of new ICT technologies for Energy Efficiency.

Three different areas related to pilot design and implementation which are often overlooked have been identified: 1) recruitment and engagement of citizens or volunteers; 2) data privacy and protection of personal data in the context of the new GDPR [4] legislation which recently entered into force; 3) monitoring strategies. Good practice and lessons learned are presented with examples from ongoing or recently finished projects. First, it will look into lessons learned in the field of stakeholder communication, the kind of incentives which have proven to be more successful for continuous engagement and how to ensure long term gains in energy efficiency. Second, we will analyse how to protect the rights of data subjects including privacy and data protection in pilot design. Lastly, we will present considerations for defining a sound monitoring strategy including advice on experimental design, hardware and software choices.

The roll out of smart meters has increased the availability of energy data from buildings and there is a growing demand for tools that allow consumers to understand their energy saving potential and to adapt their energy consumption habits. New ICT tools developed under Horizon 2020 help consumers achieve significant energy savings. If tested in well-designed pilot projects, these tools can deliver evidence-based insights in the determinants of energy use in buildings. This paper seeks to help project teams that are implementing behavioural interventions in the energy efficiency field to design successful pilots that are able to validate ICT tools in an operational environment.

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LESSONS LEARNED ABOUT USER ENGAGEMENT FOR DEMAND RESPONSE

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Keywords: Smart grid, dynamic tariffs, real-life settings, automated demand response

Pilot project Your Energy Moment 2.0, is one of several experiments in The Netherlands in which distribution system operators look for ways to unlock flexibility in the consumption patterns of households as an alternative to costly network reinforcements. The underlying premise is that households can contribute to peak shaving in the electricity networks by shifting the moments they consume electricity form the grid, or deliver electricity to the grid. This is becoming more and more relevant with the increasing amount of decentralized and intermittent electricity production (e.g. solar panels), electrification of transport (e.g. electric cars) and space heating (e.g. heat pumps).

Your Energy Moment 2.0 builds upon the results from a previous project in which we learned that, when facilitated with technology households are willing and able to change their energy consumption patterns. They were informed about the best moments to use their appliances via an in-home display; their washing machine and heat pump were 'smart', i.e. adjusting their operation times to the right moments [1].

The goal of Your Energy Moment 2.0 was to make a step towards larger scale implementation. More specifically, to gain better insight into viable business models for demand response based on dynamic tariffs in combination with electricity storage. To this end, a new business model was developed and tested with 90 households. Half of the households were equipped with a battery and a heat pump that could automatically respond to price incentives. These appliances support the households to automatically provide flexibility. All household had access to an app, which presented a forecast of the tariffs, an overview of the energy consumption and an overview of the costs. Additionally, households could see a 'Top 10' of households that performed best on using electricity at the lowest priced time slots.

Interviews and questionnaires held with participants, as well as on the experiences of the practitioners in the project provided valuable lessons concerning the households' engagement with the tested proposition. The engagement of the households showed to be a major challenge for the execution of the pilot as well as for the viability of new business models. The main lessons are:

- Make sure to align business goals and the goals and motivations of households for providing flexibility. User-centred design is key to developing a successful business model for flexibility in households.
- With the current market conditions in the Netherlands, it is difficult to interest households for an energy contract based on the potential to save money by taking advantage of dynamic tariffs.
- Providing flexibility has to be meaningful for households. Financial gains are an important

driver, but other motivations have to be addressed as well.
- Providing flexibility has to be easy for households. Manual demand response cannot be expected from everyone. Automation can be provided as part of an energy service. How to shape such services needs to be explored further.
- Participants preferred to receive information via an in-home display over an app about energy usage, appliance status and tariffs.
- Provide understandable and transparent insight into how the ‘smart appliances’ work, the incentives on which they operate. This can help the householder to make most out of the flexibility the household can provide manually and automatically.
- In order to define to what extent households have to be involved with providing flexibility automatically and manually, more insight is necessary in how much flexibility will actually be required from households to balance the electricity system.

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CONSUMER ACCEPTANCE AND PERCEPTIONS OF SMART APPLIANCES: A GLOBAL SURVEY

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Keywords: Smart appliances, consumer acceptance, concerns

1. INTRODUCTION

With the Renewable Energy Directive (2009/28/EC), the European Commission established an overall policy to foster the use of energy from renewable sources. It requires a 20 % reduction in GHG emissions and a share of 20 % of total energy demand fulfilled with renewables by 2020 [1]. Recently, Demand Response (DR) has been discussed for the residential sector as one measure to meet these targets [2]. Household appliances can offer various options of load shifting including delayed start, short term interruptions of operation of appliances or changes in operation [3, 4]. Household appliances that are “able to react automatically to external signals, e.g., turning itself following a signal from the electricity grid” are referred to as smart appliances [5].
Using smart appliances to shift loads in private homes requires some adaptations of consumer’s everyday routines and behavioural changes. Consequently, consumer acceptance and use of smart appliances is one of the most crucial key factors to make this new technology being successful [6, 7]. Up to now, there are only small pilot projects investigating consumers’ experiences with smart appliances, their perceptions and concerns [3, 5, 6, 8, 9]. With the objective of investigating consumer’s acceptance, perceptions, motivations and concerns in view of various options of load shifting in smart appliances, a global, web-based survey was carried out.

2. MATERIALS AND METHODS

The questionnaire contained 36 closed questions covering availability and the frequency of use of smart devices (e.g. smart phones, smart TV, robotic vacuum cleaner etc.) in households, acceptance, perceptions, motivations and concerns in view of various options of load shifting in smart appliances as well as demographic and socioeconomic characteristics of the participants. For the purpose of investigating various options of load shifting, five different scenarios including manual or automatic delay in start, remote control and short-term interruptions have been defined and described. Care was taken to ensure only qualified and consistent answers were recorded. The online tool SoSci Survey (http://www.soscisurvey.com) was used to design and implement the online questionnaire. Corresponding to the international target group, English language was chosen. The link to the survey was spread via social media and email. Additionally, a respective press release was issued.

3. RESULTS AND DISCUSSION

In total, 868 participants completed the survey (49.0 % female, 44.1 % male, 6.9 % no answer). 15.4 % of the respondents were younger than 30 years, 24.7 % and 25.7 % were in the age group

30-39 and 40-49 years, respectively. A share of 20.6 % was between 50 and 59 years old, 13.4 % of participants were older than 59 years. The remaining 0.8 % denied an answer to this question.
A manual delay in start-time (e.g. in the case of washing machines) was considered as useful by the overwhelming part of respondents. About 60 % of them would use such a function at least sometimes. Remote start and control functions via smart phone were less appreciated among the respondents. According to their own statement, about 42 % of them would make use of a camera built-in into the refrigerator to check food in stock remotely. The acceptance of a remote start and control functions for ovens is even lower. Only 24 % of respondents would use such a function sometimes or frequently, 53 % rejected it completely. The idea of a smart dishwasher, which starts automatically (triggered by an external signal, e.g. via power line) if surplus energy from renewables is available, is appealing for most participants. About 60 % indicated that they would make use of this function especially if an incentive from the utility is offered (e.g. cheaper energy tariff). The highest share of respondents expected reductions in energy prices between 11 and 20 %. With the exception of refrigerators, short-term interruptions in times of power shortage would be accepted by the majority of respondents. Independent of the scenario, particular concerns were expressed related to operation of appliances during absence, misuse of data by unauthorised people and loss of performance / service.
Up to now, real-life experience studies on various options of load shifting in smart appliances are verly limited. Results of two previous studies [9, 10] strongly support findings of this survey. Participants were largely willing to shift load of washing machines, tumble dryers and dishwashers if cheaper energy tariffs were offered. For convenience reasons, automated options (e.g. start automatic triggered by an external signal) were highly appreciated. For washing machines, average savings amount to 27 % of the costs [10], which are even higher than the expected savings indicated in the present study.

4. CONCLUSION

Results of the survey show that smart technologies are in principal accepted if consumers have an extra benefit, e.g. monetary or comfort. In order to enable a diffusion of smart appliances into private homes, it is necessary to meet the concerns expressed.

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MOVING FROM ENERGY-SAVING TO MINDFUL LIGHTING BEHAVIOUR IN HOMES

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Keywords: Lighting behaviour, Residential, Energy-saving, Mindful

1. INTRODUCTION

Before the phase-out of incandescent lamps in the EU, interior lighting was responsible for approximately 20% of average household electricity use in Sweden. To save energy and reduce greenhouse gas emissions, a major societal goal is to switch from light sources with low lm/W to ones with higher luminous efficacy and to reduce wasteful energy behaviour, while still meeting end user needs. A recurrent recommendation in energy conservation campaigns is to turn off lighting in non-occupied rooms. According to the PremiumLight market survey carried out in 2012 in 12 EU countries, approximately 30% of Swedish residents always turn off the lights when nobody is in the room which was well below average (65%). Why is the figure so low in Sweden? One explanation is habitual behaviour, i.e. when the intended goals of an action are reached, and the behaviour leads to the intended outcomes, the behaviour will probably be automatically repeated in the next similar situation [1]. What are the intended goals guiding this lighting behaviour in home environments? The objective of this paper is to provide a better understanding of the reasons behind the cultural practice among Swedish residents to leave the light on in empty rooms – something to consider in energy conservation campaigns directed at residents.

2. MATERIALS AND METHODS

To investigate the current lighting situation in Swedish homes, a mixed-methods research study was carried out in October-November 2015 in Lund and Malmö, Sweden. A questionnaire was sent to a random sample of 2000 residents drawn by the State Personal Address Registry from the adult population in Lund (18-80 yr); the response rate was 27% (n=536, female 51%). Semi-structured interviews (n=12) were held in parallel. Respondents compared well to the national population in terms of dwelling type. The paper-and-pencil questionnaire (11 pages, 35 questions) was adapted from the PremiumLight market survey (2014) addressing, e.g., reasons for buying a particular lamp technology, lighting behaviour at home, and placement of lamps. The interviews were held in the homes of a sample of 12 volunteers living in multi-dwelling buildings, recruited through personal networks (26-76 yr, female 50%). The interview was guided by the following question: 'How are luminaires used in homes and what are the residents' needs and wants with regard to home lighting?'

3. RESULTS AND DISCUSSION

More than half of the respondents (57%, n=301) reported that they sometimes turn off lights when nobody is in the room, 26% (n=140) always turn off lights, and 17% (n=90) seldom or never turn off lights, which is in line with the PremiumLight survey results.

A qualitative thematic analysis based on the interviews produced five key factors influencing residents' illumination choices—time, the physical setting, activities, the social situation and individual characteristics. Three are described here as only these are relevant to this paper. The first is the temporal dimension, i.e. time of year or time of day. A female participant, 53 yr, reported that when she comes home during the dark season she turns on luminaires even before taking off her shoes. As the Swedish practice is to remove shoes at the entrance, her behaviour emphasises the importance of lighting: "It creates a feeling of comfort to turn on some of the lights." Low outdoor illuminance can therefore explain why residents choose not to turn off the light in a room despite no occupancy.

A second factor is linked to individual needs and wants, such as visual comfort, safety, and creating a cosy atmosphere. Avoiding dark spaces was mentioned by several participants and keeping luminaires lit in the windows was a recurring practice. Some people are sensitive to the high contrast between bright and dark areas which can produce visual discomfort. One male participant, 53 yr, and his wife turned on a table lamp in a window "as soon as we come home even if we aren't in here. It looks so dull when it's gloomy or dark." He never leaves lights on when he leaves home, but his wife thinks that "it's cosy when you come home and lights are on." A male participant, 26 yr, leaves the small lights on in the window most of the time even when he is not at home. "It's because it's nice when you come home and something is lit. Leaving the big lights on would be a bit too much /.../". Another reason can be emotional. A male participant, 76 yr, reported a friend's thrifty practice of turning off all lights in the home except for the one where he was seated. Unlike his friend, this participant wanted more lights on because it made the dwelling more homelike, easier to move around in without having to turn on more lights, and to avoid tumbling.

A third factor involves social needs—the lights are kept on for people outside the home to make visitors feel welcome or to make people outside feel secure. It can be reassuring to know that there are people inside the buildings. The outdoor environment was a reason given by a female participant, 69 yr: "[The window light] in the kitchen is often lit when I'm not at home to give some light outside. There are mostly office spaces facing the yard so in the evenings it's unlit."

4. CONCLUSIONS

The interview comments illustrating the temporal, individual and social factors show examples of reasons for leaving the lights on in empty rooms. Light in empty rooms can be meaningful to residents, so a shift in mindset and communication is proposed from 'energy-saving' to 'mindful' lighting behaviour, which implies being kind to oneself, people and the planet. 'Mindful', or being aware, is linked to mindfulness, which is rooted in Buddhist teachings and entails respect for the needs of others and oneself. 'Sustainable' lighting behaviour is another option but may be too broad a term; 'mindful' sends the message that we have to pay attention to what we need in the present moment, avoid automatic behaviour, and also reflect on the environmental and ethical consequences of our behaviour. In other words, shift from habits to intentional behaviour. Future energy conservation campaigns directed at residents could include 'turn off the light when it's not needed' rather than 'turn off the light in empty rooms', because lighting does more than facilitate visual tasks.

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IDENTIFYING AND MODELLING TARGET GROUPS FOR DEMAND SIDE MANAGEMENT VIA FLEXIBLE HEAT PUMPS

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Keywords: Demand Side Management, heat pumps, target groups, electricity demand model

1. OVERVIEW

In this study we use findings from a conjoint-analysis (n=985) to identify target groups who are likely to participate in Demand Side Management (DSM). In particular, we discuss how they can be attracted to the adoption of flexibly operated residential heat pumps (FHPs). Furthermore, we use the eLOAD model ("energy load curve adjustment tool"), developed at Fraunhofer ISI, to model electricity demand, to examine the consequences of different market shares of FHPs for system load and system integration of RES.

2. METHODS

We surveyed 985 respondents in 2017 who live in owner-occupied dwellings in Germany to examine the antecedents that influence the willingness to adopt FHPs. The sample is representative for the population of decision-makers in owner-occupied dwellings in Germany. We conducted a rating based conjoint-analysis to investigate respondents' preferences with regard to the adoption of buffer storages coupled with a FHP. The respondents were asked to imagine that they have moved to a new home where a heat pump is already installed and the question arises whether or not they want to install a buffer storage, which costs 1,500 Euro, coupled with an autonomous control of the heat pump. Each respondent rated the attractiveness of ten offers (presented pairwise) on a six-point Likert-scale. These offers entailed the purchase of a buffer storage and varying attributes of the FHP: These are financial compensation (0 to 720 Euros) and a non-monetary bonus (none, smartphone-app for energy consumption analysis/remote control of light and heaters/anti-burglary surveillance) as well as delayed reaction of thermostats if an increase of temperature is requested (0 to 30 minutes) and the need for data exchange with a co-ordination centre (no vs. direct vs. indirect data exchange). In addition, several demographic and psychological characteristics of the respondents were surveyed. We use a hierarchical linear model with random effects to analyse the influence of the attributes as well as respondent characteristics on the attractiveness offers for buffer storages coupled with a FHP to identify specific target groups [1].
To model the possible impact of FHP adoption by the identified target groups on electricity demand and resulting avoided RES curtailment we use the electricity demand model eLOAD. eLOAD allows the generation and projection of a country's system load curve with hourly resolution based on a database of more than 1000 process-specific load profiles, weather data and annual electricity demand projections. Thereby, technological and structural changes on the demand side leading to an evolution of the system load curve are analysed. Additionally, the flexible load share can be optimised using a

mixed-integer programming approach, where load is allocated in a cost-optimal way. We examine whether load shifting of heat pumps supports balancing out high shares of RES. In this context, we determine the impact of different market shares of FHPs on the potential of integrating RES in the power system of the year 2030. Targeting minimisation of RES curtailment, we choose residual load (load minus electricity generation from PV and wind) as a central, dynamic optimisation signal to incentivize load-shifting activities.

3. CONCLUSIONS

The conjoint-analysis indicates that target groups can be characterised by technophily (i.e. how fond is a responndent of technology in general) and technology specific self-efficacy (i.e. how competent the respondent considers himself) as these psychological properties influence the general evaluation of the offers as well as the influence of the attributes of the offers for their evaluation. A high financial compensation is important to win especially technophile respondents for a FHP. In contrast, respondents who have a higher self-efficacy value financial compensation less while striving to avoid comfort losses by delayed reaction of thermostats. Independently from the respondents' characteristics reducing the need for data exchange for a flexible operation of heat pumps is important, as privacy concerns turn out to be an influential barrier to FHP adoption.

	Share of FHPs in Germany in 2030		
	25%	**50%**	**75%**
Reduction of negative residual load in 2030	3.0 %	5.7 %	6.5 %
Additional potential for RES integration by means of DSM in 2030	45 GWh	87 GWh	100 GWh

Table 1: Reduction of negative residual load and potential additional RES integration for different FHP shares

The analysis with eLOAD shows that a relevant additional amount of RES can be integrated into the electricity system by the diffusion of FHPs (cf. table 1). As the marginal benefit of FHPs regarding RES integration decreases, it seems promising to focus on DSM-affine target groups using tailored offers instead of striving for a "one size fits all"-approach to support FHP adoption. In the presentation, we will discuss how these findings can be further utilised in eLOAD. In particular, we will look deeper into DSM approaches that minimise the need for data exchange (such as strategies maximising self-consumption that reduce the necessity to communicate with external devices and actors) and their impacts on potential for RES integration in comparison to approaches that require data exchange. Furthermore, we will discuss to what extent especially technophile and persons as well as individuals with a high self-efficacy constitute target groups which are sufficiently large to leverage substantial RES integration. In this context, we also investigate the amount of financial incentives necessary to attract these target groups.

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Bringing the Service Perspective to Understand Customer Engagement and Value Co-creation with Smart Energy Services

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Keywords: Customer Engagement, Value Co-Creation, Smart Grids, Smart Energy Services

1. INTRODUCTION

Customer engagement with smart energy services is a priority for the European Union, and its main research and innovation focus is on the areas of smart service design and active customer engagement [1], as smart grids are deeply changing the paradigm of energy production and consumption [2]. However, the energy sector is facing challenges in the process of deployment of this technology at the low and medium voltage levels, due to the lack of customer engagement with energy services [3], representing a huge barrier to adoption. Hence, more research is required to meet this challenge, in order to generate relevant inputs for the development of new smart energy services [4], which encompasses the integration of new actors in this new ecosystem to co-create value within a multistakeholder service network [5]. In this context, the holistic nature of services brings contributions to understand and foster customer engagement with smart energy services, having the co-creation of value as an outcome. From the service perspective, customers are active co-creators of value, and service is an enabler of value co-creation, together with other resources in the customer value network [6]. Additionally, customer engagement is defined as a psychological state that occurs in the function of interactions in co-creative customer experiences in particular service relationships [7]. Both perspectives, emphasize customers' contributions to interactional and co-creative of value processes, network centered and, thus, inherently relational [8].

This paper integrates smart grid and service perspectives to understand the role of customer engagement with smart energy services and, how value is co-created through this. The study consisted of a qualitative study covering customers of home energy management systems (HEMS), electric vehicle (EV) customers and residential customers with high consumption of electricity. The study has been developed in a European project H2020 in partnership with a Portuguese energy company and the Faculty of Engineering of the University of Porto.

2. EMPIRICAL STUDY AND RESULTS

The study involved focus groups and in-depth interviews with a total of 31 participants covering three groups: customers of Home Energy Management Systems (HEMS) (11), electric vehicle (EV) customers (10) and residential customers with high consumption of electricity (10). These groups were selected as they adopt different roles in the smart energy service ecosystem and different levels of proactivity regarding the service offering. A partner utility company from the European project consortium provided the sample of customers of HEMS and high consumption and EV customers were recruited in social media.

Study results showed that these three groups present different levels of customer engagement and are motivated by different value co-creation goals. HEMS customers, as early adopters, are independent, meaning that they implement the system on their own or they can eventually hire a full-service to support their daily activities. They are well informed and are willing to control and manage energy consumption to achieve their main goals - savings and energy efficiency. EV customers are proactive and part of a large community that shares daily experiences of use, besides management and functionalities issues that are not available in manufacturers' information channels. The daily activity plans of the car are based on the community inputs and support services, as such, application data and websites. EV's are important ecosystem components, as they consume a significant part of

the house energy, pushing the customer to take decisions regarding the charging routine in off-peak periods or use public stations, and set arrangements in home electrical installation. Additionally, the car battery can be useful to support the energy customer to manage the power supply of a house during the night. Residential customers with high consumption of electricity are not aware of smart grids technology or smart energy services, therefore they are not advanced or independent users as the other groups. However, they showed interest in full-service value propositions that provide the benefits, but not the hassle of adopting a new mindset and behavior regarding energy consumption.
These results also provide useful insights for energy service providers to engage and co-create value with these different groups of customers. In case of HEMS customers and EV customers, they want to be in control of their consumption decisions. In this context, smart service providers and customers should offer a value proposition that enables them to interact in real-time to adjust dynamically their demand, pushing operators to adjust their procedures and resources to offer the service efficiently. On the other hand, residential customers with high consumption of electricity do not necessarily want to assume active roles in service provision. Energy service providers have the opportunity to develop a full service for these customers that reap the benefits of smart energy services. In this case, service providers can operate based on forecasts over time, adjusting their operations accordingly.

4. CONCLUSION

This study brings a service perspective and shows how it can contribute with solutions for engaging customers with smart energy services, taking into account value co-creation as a relevant outcome in this process. Based on the results of the empirical study, customers wish to play different roles to co-create value and reap benefits from the grid, and not all of them want to play an active role. In this context, full-service offerings can engage these customers by understanding how they respond to different interactions and relationships in the service network according to their goals towards energy consumption and management. These results highlight the need to focus on value co-creation with customers and other actors in the value network, in which customer engagement plays a crucial role to achieve the final goals.

AKNOWLEDGMENTS

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REDUCING SINGLE-USE WASTE: DETERMINANT FACTORS FOR THE USE OF REUSABLE DISHES ON A UNIVERSITY CAMPUS

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Keywords: pro-environmental behaviour, norm activation, theory of planned behaviour, packaging waste, sustainable consumption, university campus

EXTENDED ABSTRACT

Packaging plastics, designed for single use only, account for almost half of the globally generated, increasing amount of plastic waste [1]. The (inappropriate) disposal of plastic entails environmental, health and economical damage [1]. Therefore, actions to curb single-use plastics are required.
In catering industry, single-use materials, such as disposable dishes for meals to take away, are in wide use. The aim of the present study is to investigate determining factors for the usage of reusable versus disposable dishes on the campus called *Toni-Areal* in Zurich (Switzerland).
Whereas many studies on environmentally relevant behaviour concerning waste investigate the recycling domain, yet very few is known about behavioural factors and decisional processes determining a reduction of waste by the usage of reusable instead of disposable products.
The theoretical framework of the present study builds on a meta-analysis by Bamberg and Möser [1]. Their study investigated psychosocial determinants to explain pro-environmental behaviour. In the present study, these determinants are adopted to identify predictors for the usage of reusable dishes, as a pro-environmental behaviour. The examined corresponding predictors include self-interest as well as pro-social motives. Self-interest items mainly base on the *theory of planned behaviour (TPB)* [4]. Thereof the constructs attitude, perceived behaviour control and intention are included. The factors social norm and moral norm, the core factor of the *norm activation model* [5], cover normative considerations. Furthermore, two cognitive preconditions for developing moral norms are measured, namely causal attribution and problem awareness of environmental issues (caused by usage of disposable dishes). Additionally, feelings of guilt (when using disposable dishes) are considered. However, besides empirical psychosocial determinants, decisions as to whether use reusable or disposable dishes can depend on specific contextual conditions. To identify relevant situational factors on the considered campus, participants were asked on their subjective reasoning for, and places of consumption by, using disposable respectively reusable dishes.
An online survey with students and staff of the campus, generated 283 self-reportedly completed datasets. Participants were asked to rate the frequency of using reusable dishes, when buying food on the campus, on a 7-point scale reaching from *never* to *always*. Items evaluating the psychosocial predictors contained given questions or statements. Answers are given on a 7-point scale, reaching from total agreement to total disagreement. Over all, the examined items for psychosocial constructs showed acceptable to good consistency. Quantitative and qualitative questions capture subjective reasons and places of usage.

Multiple regression analyses identified intention (β=.22) and perceived behaviour control (β=.20) as the only significant, direct predictors of the usage of reusable dishes (R^2=.13). These findings are in line with the TPB. The main predictor of intention is moral norm (β=.62), whereas internal attribution (β=.14), problem awareness (β=-.12) and perceived behaviour control (β=.10) have significant, but weaker impacts on intention. Frequency analysis reveal that the main reasons for the usage of reusable dishes are to prevent waste production (rated by 82% of all participants), and a general preference of reusable dishes (76%). For disposable dishes, the reason that people do not have to bring back the dishes to the canteen (34%), was rated most frequently. Whereas participants use reusable dishes mainly close to the canteen (68%), they use disposable dishes most frequently in other places inside of the building (34%).

Yet, the explanatory power of the results is limited. The sample is not fully representative for the campus, due to unbalanced ratio of gender and affiliation to study departments, and possible selection biases due to the voluntary participation on the study. Moreover, social desirability might have affected the answers due to self-reported data.

Nonetheless, results provide indications for interventions to promote the usage of reusable dishes on the campus. Intentions are the main determinants of the usage of reusable dishes. To increase intentions, normative interventions to strengthen moral norm are advisable. Furthermore, results of psychosocial as well as situational variables examined, emphasize the importance of perceived and actual behaviour control. Hence, interventions should include infrastructural improvements to facilitate the usage of reusable dishes. Recommendable measures include the provision of reusable dishes to take away and more return stations for dishes in various places.

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NEW DETERMINANTS OF BEHAVIOUR CHANGE: TRIGGERING ENERGY SAVINGS THROUGH PROFITABILITY AND SELF-SUFFICIENCY OF PHOTOVOLTAIC BATTERY SYSTEMS

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Keywords: Energy savings, Photovoltaic Battery Storage Systems, Profitability, Self-sufficiency, Energy-related behaviour

1. INTRODUCTION

According to the targets of the German federal government, the electricity consumption shall be reduced by 25 percent by 2050, and the share of electricity generation by renewable energies shall be 80 percent of the gross electricity consumption in 2050 [1]. While the share of renewable energies has been increasing continuously during the past years, the energy consumption has only declined slightly. As the present trend will not be sufficient to meet the government's objectives, a new innovative approach will be necessary to achieve more ambitious electricity savings. [2]

Private households play an important role with regard to the envisaged reduction of the national electricity consumption. To date, subsidy programmes related to energy savings have been primarily targeted to reduce the electricity bills of low-income households. However, further potentials for energy savings lie in households with medium to high incomes and comparably higher electricity consumption. It is generally observed, that they do not take the initiative to consult electricity saving advisory services as they do not feel any financial pressure to lower their energy costs. On the other hand, households with medium to high incomes are addressed by subsidy programmes related to market and technology developments in the field of renewable energies, such as financial support for the installation of photovoltaic systems or stationary photovoltaic battery storage systems.

In 2016, already almost every second photovoltaic system up to 10 kWp in Germany was installed in combination with a battery system. [3] And for the coming years a significant growth in the number of battery systems can be expected due to national subsidy programmes. The interest in solar battery systems will be further ignited by the first feed-in compensations for old PV-systems under the Renewable Energies Law (EEG) expiring as well as by falling costs for lithium-ion batteries.

According to the annual scientific monitoring programme of photovoltaic battery systems ("Speicher-monitoring 2017"), proactive participation in the German "Energiewende" and hedging against increasing electricity prices are listed as main motivations for the investment in a battery system. Generally speaking, the major share of customers of PV battery systems can be ascribed to "innovators" or "early adopters" who are highly educated, prosperous and interested in new technologies. At the same time, they often have significantly above-average electricity consumption. [3]

2. RESEARCH APPROACH AND RESULTS

The research project [4] funded by the German Federal Ministry for Education and Research systematically addresses households that are currently planning to invest into a photovoltaic system or a photovoltaic battery storage system to increase their self-consumption and degree of self-sufficiency. As a basis of decision-making for the investment, profitability calculations over a long-time horizon of twenty years are often provided. Initial analysis of available online calculation tools shows that none of them takes into account the effects of energy-saving measures on the overall profitability.

Öko-Institut and Büro Ö-quadrat have developed a Cost Efficiency Calculator “Stromspar-Speicherrechner” which can be used to determine the profitability of investments into photovoltaic systems or PV battery systems in combination with investments into energy-saving measures for private households. The tool uses hourly household electricity load profiles and climate data to model the photovoltaic electricity generation and the charging/discharging of the battery storage system. It allows users to specify their energy-saving target and estimates the associated costs. Profitability is calculated based on the investment costs into the photovoltaic battery system, costs of the energy-saving measures, the electricity bills and the feed-in revenue over a time horizon of 20 years. Exemplified for three typical scenarios, the calculator demonstrates that the most economical outcome of PV battery investments is generally achieved in combination with energy-saving measures.

The authors expect that reasoning by “profitability of investments” of energy saving measures will be more appealing to middle-class households than merely campaigning for reducing electricity bills. Crucially, the target group of households is accessible at a time when they are willing to make a major investment in a PV/battery energy system. The calculator was initially tested in five households in combination with electricity saving advisory service. All test households showed interest in implementing some of the electricity saving measures identified during the on-site consultations. Although as the first priority, mainly low-cost measures were planned, the households also expressed their willingness to invest in energy saving measures such as replacement of inefficient appliances.

3. CONCLUSIONS

The newly developed advisory tool is particularly suitable for organisations in the field of consumer and energy advice services. It is Excel-based and comes with a user-friendly interface that can be readily used by energy consultants. New target groups can be opened up in terms of energy saving measures. Especially medium to high income households can be addressed at the time of investment decisions for photovoltaic or battery storage systems. The advisory tool clearly demonstrates the advantages of additional investments in energy saving measures: i.e. hedging against increasing electricity prices, increasing self-sufficiency and being profitable. Thus, behaviour change can be triggered by combining profitability and self-sufficiency calculations of photovoltaic battery storage systems with the complimentary effect of reduced energy consumption.

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THE HOW AND WHY OF SHORTER SHOWERS: LONG-TERM EFFECTS OF CONSTRUAL LEVEL AND REAL-TIME FEEDBACK ON ENERGY CONSERVATION

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Keywords: construal level theory, real-time feedback, environmental values, water conservation

INTRODUCTION

One challenge for policymakers within the domain of pro-environmental behavior is to not only change one-off decisions or realize short-term behavior change, but to have a lasting impact on individual day-to-day decisions and habitual behavior. Although habits have a persistent effect on pro-environmental behavior [1], the formation and maintenance of these habits have been studied less [2]. When people take on a new behavior, or want to form a new habit, they can think of this behavior in different ways. They can focus on how to perform the new behavior, and thus think of it in a very concrete manner. Alternatively, they can think of the underlying reasons for acquiring this new behavior by thinking of why they should perform this particular behavior. This distinction is captured in construal level theory, where the how question is related to a low construal level, and the why question to a high construal level [3]. Construal level in turn influences the way people make decisions, and behave, and may thus influence how long-lasting newly formed behaviors are.

FIELD EXPERIMENT

As people can be motivated to start a new behavior by knowing exactly how they could do it or why they should do it, this research aims to investigate which one method has more long-lasting effects. We focus on a very habitual behavior at home: showering. To activate the behavioral change, we randomly assigned 92 participants to a high or low construal level manipulation (i.e., an adjusted version of the “How versus Why” task [4]) and provided all participants with real-time feedback on their shower use for one month. For real-time feedback, we installed the Amphiro device, which is powered by the flow of water and displayed the following information: energy label, temperature of water, energy consumption (i.e., to heat up the water), number of liters and a polar bear animation (see [5]). After one month, the feedback device was removed, and we tested whether a high or low construal level manipulation had a more lasting effect on shower behavior and other related pro-environmental behavior. During the duration of the experiment (i.e., three months) we unobtrusively and objectively measured individual daily water and energy use before, during and after the installation of the real-time feedback device.

EXPECTATIONS

We hypothesized that low construal level thinking would be especially effective for short-term behavior change, whereas high construal level thinking would lead to more lasting effects on reduced water use. Moreover, we were also interested in the potential moderating effects of biospheric values (i.e., how much participants value the environment). We expected that participants who scored lower on biospheric values would use more water in the baseline period and would thus have more ‘room for improvement’ in terms of reducing their water use. Finally, we were also interested in the potential spillover effects to other energy-related behaviors (i.e., electricity use) and expected participants in the high construal level condition to portray more positive spillover behavior.

RESULTS

Our results indicated that all participants, irrespective of construal level condition, reduced their water use significantly when receiving real-time feedback (-17%). Upon removal of the device after one month, all participants increased their water use again, but still used 10% less water as compared to their baseline use. Throughout the intervention periods we did not find significant differences between the construal level manipulations. However, we did find that once the feedback device had been removed, participants who scored higher on biospheric values were more likely to remain at a lower water use level when they were in the high construal level condition as compared to participants in the low construal level condition. This result implies that participants who value the environment are affected most by our high construal level manipulation, and that the one-month intervention period does have long-lasting impact on water use behavior. Besides the effects on the target behavior, we will also discuss the effects on electricity use, showing an overall positive spillover effect on both light use and socket use.

CONCLUSIONS

In sum, our field experiment shows that real-time feedback is a very effective method to decrease water use, but also has a positive (spillover) effect on related energy-use behaviors. Moreover, once participants do not receive real-time feedback anymore, their water use is still lower than their baseline use, indicating a change in their shower habits. When taking individual differences into account, the high construal level manipulation in combination with real-time feedback has the highest potential in long-lasting effects among people who value the environment. We will discuss the implications of these findings in terms of how it adds theoretically to construal level theory and practically in terms of applications to intervention programs and future research directions.

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THE ELECTRICITY FOOTPRINT OF EVERYDAY LIFE – HOW ACTIVITIES SHAPE LOAD PROFILES

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Keywords: Time-use, energy demand, behaviour, load profiles

1. INTRODUCTION

The timing of electricity demand could play a critical role for the extent to which variable renewable energy sources can be integrated into future energy systems [1]. Load profiles provide some insight into the dynamics of everyday life. Physical characteristics and socio-demographic factors can also explain some, but not all of the diverse differences in overall use and temporality of residential demand. Time-use data has the potential to yield valuable additional insights [2-3].

We present early results of the first study of its kind, collecting electricity use and activity records in parallel. The relationship between these rich sources of data opens up new opportunities for a better understanding of social trends and behavioural patterns that drive electricity use. In this abstract we focus on common activities, such as 'hot drinks', to establish how useful they are as predictors of electricity use in time.

2. METHOD

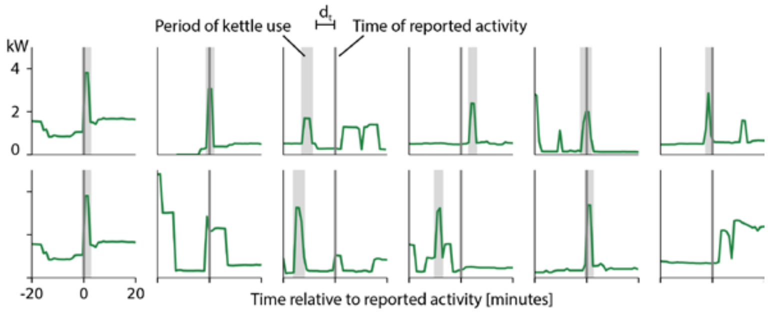
Electricity and activity records are collected from UK households as part of an ongoing study [4]. Members of 140 participating households provided over 7500 activity records using an app from 5pm to 9pm the following day. The app discriminates over 150 activity types. Electricity readings are taken with 1 second resolution. Participation is voluntary and biases include a prevalence of high incomes and high energy awareness.

3. RESULTS

3.1. The precision of reporting – 'hot drinks'

Reporting of 'hot drink' related activities lend themselves to testing the accuracy of the activity records. 53% of individuals and 73% of households reported hot drinks or use of a kettle during their day at least once, such that 361 events can be analysed.

Figure 1 shows the accuracy with which the electricity signature of kettles used for the preparation of hot drinks matches the reporting of the activity. In 74% of cases such an attribution could be made in the surrounding 20 minutes. The temporal accuracy in Figure 2 is encouraging for further analysis.



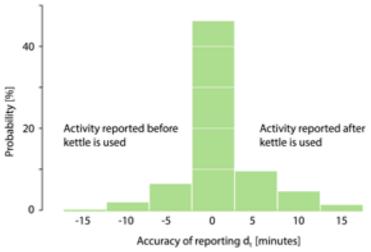


Figure 1: Examples of temporal coincidence of activity and electricity. **Figure 2: Temporal error**

3.2. The predictive power of activities

Figure 3 shows a rich diversity in energy use during different activities. At the same time, very similar activities can be performed with vastly different electricity footprints. Laundry for instance is high when performed with the help of a machine, and low when carried out manually. We will present complex intra-household dynamics, which can blur the simple delineation between high and low energy activities, many of which overlap in time and between household members.

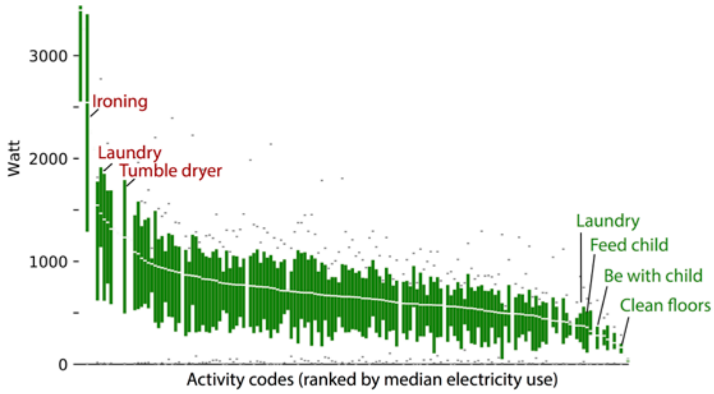


Figure 3: Electricity use at time of activities Median ±25th percentile

4. CONCLUSIONS

The combination of activity and electricity records can provide new insights into some of the underlying dynamics shaping electricity use. The example of 'hot drinks' and kettle signatures shows high temporal accuracy of app based activity records, which can therefore be used for analysis of the relationships between the two. Our findings suggest however that additional care needs to be taken when modelling household electricity use solely from time use records. Activities that are seemingly high consuming can be performed with little electricity, while others coincide with electricity footprints of other activities or other household members. The energy specific framing of activities deployed in this app based approach and the ability to explicitly report appliances, can therefore form the basis of more accurate time-use records for the purposes of load regression analysis.

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INVESTIGATING THE INFLUENCE OF PHYSICAL AND OCCUPANT FACTORS ON ENERGY AND ENVIRONMENTAL PERFORMANCE OF FOUR IDENTICAL MODERN FLATS IN UK

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Keywords: Occupant behaviour, building performance evaluation, real world case study

1. INTRODUCTION

This paper uses a real-world socio-technical building performance evaluation (BPE) approach to investigate the influence of physical factors (form, orientation) and occupant factors (number of occupants, occupancy pattern, heating schedule) on gas and electricity use (during the heating period) of four new-built modern flats located in the same housing development in Southeast England. The study is designed to provide new evidence to understand the causes of the variation in actual energy use of dwellings built to the same construction standards (building fabric thermal performance) and occupied by residents with similar economic status (high income). The four flats were designed and built to higher thermal standards: measured air permeability was $4m^3/hm^2$ against the permitted value of $10m^3/hm^2$.

2. METHODS AND CASE STUDY FLATS

In-situ monitoring of indoor environment and energy performance of four flats was carried out using established techniques of BPE [1,2]. Energy use (gas and electricity) was monitored every 5 minutes using remote metering, while indoor environmental conditions (air temperature, relative humidity, CO_2 levels) were monitored using data loggers. Data on occupant behaviour [3] (heating set-point temperatures, heating schedule and windows opening) were gathered using questionnaire surveys, activity log sheets (diaries) and semi-structured interviews along with physical monitoring of radiator temperature (heating patterns) and opening-closing of windows using state loggers. Monitoring and survey data were gathered during the heating season, from October 2017 to February 2018 (5 months).
The four flats are located in the same block, but differ in terms of orientation, location (floor), size and occupancy (Table 1), comprising two bedrooms and three bedrooms, with northern and southern orientations, located on the top, middle and ground floors. Occupancy varies in terms of number and age of occupants, time spent at home and activities carried out (Table 1).

Flat	Total floor area (TFA)	Location	Orientation	No. of occupants	Age range	Occupancy type	Heating set point
N31	67	Top floor (4th)	NW - SE	1	46-55	Working from home	20 °C
N15	72	Mid floor (2nd)	NW	2.5	25-35	1 working from home 1-3 days per week, 3 people on weekends	22 °C
N33	86	Top floor (4th)	NW-NE-SE	1	over 65	Mostly at home	19/21 °C
N06	95	Ground floor	SE	1	56-65	Variable pattern during weekdays, guests on weekends	18/21 °C

Table 1: Physical and occupancy characteristics of the monitored flats

3. ENERGY USE: IMPACT OF PHYSICAL AND OCCUPANT FACTORS

Despite being constructed to same thermal performance standards, gas and electricity use in the four flats was found to vary significantly (Table 2). The total energy use (gas for space heating and hot water; and electricity use for appliances and lighting) of the four monitored months varied by more than 50% - from 3076kWh in flat N33 to 4830kWh in flat N15. Electricity use in N31 was nearly double that of N06, despite being smaller in size and inhabited by the same number of occupants (n:1). These results indicate that energy use may not be determined by dwelling size or number of occupants.

Flat	TFA	Total Energy used (kWh)	Gas use (kWh)	Electricity use (kWh)	External surface to TFA
N31	67	4237	2499	1738	1.40
N15	72	3076	2013	1063	0.39
N33	86	4830	3781	1050	1.48
N06	95	3530	2627	903	1.43

Table 2: Monitored energy use over the period October 2017 – February 2018

Interestingly strong association was found between gas use and ratio of external surface to total floor area – flat N33 had the highest gas use and external surface to TFA, while flat N15 had the lowest. This is probably because higher the external surface area, the higher is the heat loss, resulting in more space heating which forms the majority of gas consumption in the monitored months (heating season). For this reason, the flats located on top (N31, N33) and ground floors (N06) used much more gas than the mid-floor flat (N15) which had the least number of exposed sides. This happened even though N15 had the highest heating thermostat temperature set (22°C) and the largest amount of hot water use amongst all the flats. In terms of gas use, physical factors such as location and form appeared to be more significant than occupant related factors. Conversely, no correspondence between physical factors (size of the flat) and electricity use were found. Electricity use in N31 was found to be almost two times more than in N06 (Table 2) despite being smaller in size and having one occupant each. However in flat N31, as evident from the occupant and appliance survey, the occupant used a large number of electrical appliances constantly for entertainment (wide screen TVs and powerful sound systems) and ICT (desktop pc, laptops, tablet and smart phone).

4. DISCUSSION AND CONCLUSIONS

The present study has systematically shown how physical and occupant related factors influence actual energy use of modern flats designed to high thermal performance standards. Physical factors such as location (floor) and ratio of the external surface to the total floor area were found to have a significant influence on gas use (for space heating), much more than dwelling size or heating thermostat temperature. On the other hand occupant factors related to occupancy pattern, number and use of electrical appliances have a bigger influence on electricity consumption, which forms an important share of total energy use in low energy buildings.

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ENERGAWARE: A PILOT LONGITUDINAL EXPLORATION OF A NEW SERIOUS GAME TO REDUCE ENERGY DEMAND IN SOCIAL HOUSING

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Keywords: Energy efficiency, serious gaming, digitalization, behaviour change, social housing

ABSTRACT

Introduction: We present the results of the EU Horizon2020 funded multi-disciplinary EnerGAware project: a 12-month longitudinal pilot study into the role of digitalization and gamification of energy consumption practices as a means of increasing energy awareness and reducing energy demand within the social housing sector. Social housing is provided for low-income households across most countries in Europe [1]. In the UK, 72% of households living in social housing have an income in the two lowest quintiles, so financial pressure in these households is high [2]. One result of this is that the experience of 'fuel poverty' is common. Indeed, the percentage of the population declaring they are unable to keep their home adequately warm increased from 5.7% in 2005 to 10.6% in 2013 according to EU SILC [3]. Reductions in, and more efficient use of, energy through efficiency improvements and behaviour change is hoped to provide an opportunity to address fuel poverty in this sector. One avenue of behaviour change research concerns the development of digitalized ICT-based educational tools, such as 'serious games'. Serious games are formalized, goal-oriented games, designed to go "beyond the role of entertainment" [4], and instead in directions that aim to educate, improve knowledge, or promote health and well-being. Examples of serious games being effectively used to motivate positive behaviour change abound across many domains, including health, education, and sustainability [5] [6]. Research has shown many people respond well to 'playful' forms of engagement and feedback with serious topics [7], but they are at an early stage of development in the field of energy. As such, serious games may offer a novel way to engage social housing residents with energy use. Thus, the main aim of the EnerGAware project was to explore and trial a new serious game; 'EnergyCat', aimed at motivating positive behaviour change and reducing energy demand in social housing. The game provides users with a virtual home, in which they assume the role of an 'Energy Cat', who aims to teach the human residents about best practices in energy savings.

Method: 82 social housing residents (37 male, 40 female, 5 unknown, age ranges 26 – 84) in Plymouth, UK, were randomly selected to take part in the study from a large pool of all 2772 social houses managed by project partner DCH. At the start of the trial, all participants were given a tablet as an incentive for taking part. For the experimental group (N=42), this tablet had a pre-installed version of the game 'EnergyCat', which subjects were invited to play for the duration of the trial period, for as long and as frequently as they liked. In the control condition (N=40) subjects were given a tablet, without the game. Subjects from both groups completed a baseline questionnaire designed to assess prior energy awareness, and self-reported engagement in energy efficient behaviours. In order to explore energy awareness, participants were asked to rate the extent to which they agreed with statements such as '*I often think about how I could save energy*'. Energy-saving behaviours were assessed by asking subjects to rate how frequently they engaged in 23 specific energy saving behaviours, such as '*I try to minimise my shower time to 5 minutes*'. This questionnaire was then repeated at the end of the 12-month period ('final-term' stage) to explore impact of the intervention over time. We also explored the main barriers to behaviour

change at the final term stage, in order to determine which factors, if any, may help to explain any impact of the game on participants' energy-related behaviours. This was done by asking subjects to rate the extent to which each of 11 potential reasons currently prevented them from using less energy at home. These included '*health reasons*', '*no personal control*', and a measure of general interest in energy saving: '*I am not interested*'. We also explored qualitative perceptions of the game and interest/motivation to play in the experimental group, in order to help inform future efforts. The final term survey showed 41.4% of subjects in the experimental group reported playing the game, at an average of 17 times, for an average duration of 16.5 minutes.

Results: A repeated measures ANOVA revealed no effect of playing the game on likelihood of engaging in the 23 different energy saving behaviours at the final term stage: $F(1,55) = 2.28$, $p = .14$, $\eta^2 = .04$, and no interaction between time and condition: $F(1,55) = .13$, $p = .72$, $\eta^2 = .002$. However, there was a significant main effect of time on energy awareness, across conditions: $t(55) = 2.10$, $p = .04$; in line with predictions, subjects were more likely to state they did *not* understand how their homes used energy at the baseline vs. final term stages (*M*'s = 3.52 vs. 3.11). In sum, the results provide no evidence that the serious game was able to motivate behaviour change in this context. However, participation in the programme was found to have some positive effects on behaviour. Exploration of the 'barriers to behaviour change' revealed generally high interest in energy saving within the social housing sector, whilst three barriers were identified as playing a key role in preventing further behaviour change in this context: 1. '*I don't want to feel uncomfortable at home*', 2. '*Health reasons*', and 3. '*Already using very little*'.

CONCLUSIONS

Overall, participation in the project was found to lead to a general increase in energy awareness, across conditions. However, there was no evidence that the serious game was able to motivate behaviour change in this context, with no impact of gameplay on engagement in the energy-saving behaviours. Analysis of the barriers to behaviour change data showed this was not due to a lack of interest, but more likely attributable to a desire to maintain comfort levels, health reasons, and the fact subjects perceived they were already using very little energy. What is more, qualitative feedback gathered from the experimental group at the final term stage showed that the complexity of the game and lack of support were critical issues which prevented people from effectively interacting with the game. In addition, many subjects did not perceive that the game was linked to their behaviour in real life, providing a key explanation for the lack of any real life behavioural changes as a result of playing the game. Determining means of overcoming these issues should be prominent considerations in the development of future interventions in this context. In addition, results from the current research highlight that it may be possible to improve the persuasive potential of future serious game interventions if the educational functionality of the game is improved – with a particular focus on teaching users how they can reduce consumption whilst maintaining thermal comfort at home. Incorporating this feedback into new serious game designs may prove a highly effective means of reducing energy demand in the social housing sector.

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COPING WITH A GROWING NUMBER OF E-TAXIS: A STATED ADAPTATION APPROACH ON DRIVING AND CHARGING PATTERS IN GREATER STOCKHOLM

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Keywords: Electric vehicle taxi, charging, driving patterns, stated adaptation, mixed methods

1. INTRODUCTION

Taxi fleets have the potential to be an attractive adoption group for electric vehicles due to their intense usage compared to private vehicles. The low operating costs of electric vehicles can therefore compensate for their high upfront investment cost [1]. Despite their potential, the market share of electric taxis (e-taxis) is still minuscular in most of the world's cities. Several cities in China are exceptions. In a previous study in the greater Stockholm area it was found that e-taxis can be more profitable for its carriers compared to conventional taxis [2]. A result explained by the low operating costs of e-taxis and high demand for e-taxis due to priority at the international airport in Stockholm and through the novel private initiative *Nollzon.* The small proportion (≈1%) of e-taxis in the examined case company meant that these aspects yielded a significant competitive advantage for the e-taxis in operation. Profitability is a key adoption parameter for profit maximizing agents such as taxi carriers, but it is nevertheless not clear if the current profitability advantage of e-taxis will hold in future market conditions.

2. PROBLEM STATEMENT AND OBJECTIVES

In a previous study [2], it became clear that the intensive driving and charging of e-taxis has led to queues at the available charging infrastructure already now. When the number of e-taxis would grow in the future, it is believed that capacity constraints of charging infrastructure will become more and more apparent. Moreover, even though e-taxis are prioritized both in inner city zones (Nollzon) and at the international airport of Stockholm, the value of these prioritization mechanisms is likely to change with an increasing number of e-taxis. In order to cope with changing conditions for driving e-taxis in Stockholm, taxi drivers need to change their driving and charging behaviour. The aim of this study is to investigate behavioural strategies of e-taxi drivers and carriers to cope with changing demand and charging conditions due to an increasing number of e-taxis.

The following research questions have been formulated:

1. How do e-taxi drivers change their intended driving and charging patterns in case e-taxis would be a substantial part of the total taxi fleet (10% and 50%)?
2. Are e-taxi drivers likely to change their charging behaviour due to the introduction of temporal price differentiation for electric vehicle charging?
3. How do e-taxi drivers trade-off between monetary cost and time cost for charging?
   - Are e-taxi drivers willing to pay a premium for ultra-fast charging?
   - Are e-taxi drivers willing to wait in a queue (20 min) in order to use free charging?
4. How do e-taxi drivers change their behaviour in a zero-emission zone scenario?

3. METHODOLOGY

Based on an analysis of capacity and usage data of electric vehicle charging infrastructure as well as data analysis of the demand and success rate of Nollzon priority orders, scenarios had been designed for a stated adaptation experiment that was carried out among 15 taxi drivers, some of whom are carriers as well. A stated adaptation experiment [e.g. 3] takes current behaviour as a starting point and behavioural responses to several hypothetical scenarios are investigated. Compared to other types of stated preference experiments, stated adaptation experiments have a more realistic basis because they are based on real initial behaviour. The stated adaptation experiment has been carried out with one-to-one deep interviews.

4. PRELIMINARY RESULTS AND CONCLUSIONS

It is clear that there is a high degree of excess demand for E-taxis originating from Nollzon currently, this overcapacity in demand can likely sustain a quite large increase in number of E-taxis in the future. In regards to charging the situation is more challenging. Already in the current situation, queues at charging station are no seldom phenomenon. The peak hours depend from location to location, but at noon and early afternoon, there is a clear peak in the use of fast chargers in Stockholm. An increasing number of EVs and especially e-taxis is likely to cause severe capacity problems at certain hours of the day, even if the charging infrastructure would increase at the same pace as the deployment of EVs. In general, taxi drivers are aware of the capacity problems. Their behavioural responses are slightly dependent on whether they are carriers as well, as well as on what type of e-taxi they drive. Their ability to change charging time without compromising profitability is in some cases limited. However, generally there is a positive attitude towards ultra-fast charging, which decreases the time needed for charging and at the same time increases capacity. Clear differences between the awareness of e-taxi drivers and their stated ability to cope with changing conditions have been observed. Into the future, the distribution of costs and benefits between drivers and carriers needs to be adapted to the specific context of E-taxis. Using e-taxis might be more profitable for carriers, but the need to charge the vehicle implies time costs on taxi drivers. Some compensation mechanisms would therefore be desirable. Moreover, the use of e-taxis will become an increasingly complicated task due to the fact that priority bookings might decrease and more queues at charging stations are to be expected. More education for beginning e-taxi drivers and tools to assist e-taxi drivers with demand and charging infrastructure during their work shifts are recommended into the future.

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VALUE-BASED MESSAGE FRAMING AND POLITICAL DECISION-MAKING IN THE ENERGY DOMAIN

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Keywords: Real-world events, political voting, value framing, political ideology, Swiss energy act

1. INTRODUCTION

Political voting is a crucial aspect of environmental decision-making. In many countries, voters decide whether or not large-scale energy programs are put into effect. For instance, in May 2017, the Swiss citizens voted on the implementation of the nation-wide energy act, which is accompanied by fundamental changes in the energy system toward more renewable energies. Previous research suggests that these political voting decisions are substantially affected by the core values voters endorse, that, in turn, are largely determined by voters' political orientation [1],[2]. Thus, research has shown that left-oriented voters are more likely to endorse values referring to fairness, openness-to-change, and care of others, while right-oriented voters are more likely to endorse values referring to tradition, authority, and purity [1],[2],[3],[4]. In accordance, framing messages in terms of harm/care, which emphasize the harm and destruction that humans are causing to the environment, resulted in stronger environmental policy approval among left-oriented but not among right-oriented individuals. However, framing environmental messages in terms of purity/sanctity, by emphasizing how environmental pollution may contaminate the purity of nature, rendered right-oriented voters more likely to approve environmental policies [3].

In the present research, we aimed to examine the influence of value framing on voters' political decision-making in the context of the referendum on the Swiss energy act. Thus, this study is among the first that examines framing effects with respect to a real-world political event with immense environmental relevance. We expected presented arguments in favour or against the Swiss energy act to impact voting decisions as a function of voters' political orientation (left/right-oriented). Specifically, we expected arguments to be more influential when they are based on values referring to voters' respective political orientation.

2. METHODS

Overall, 933 eligible voters who actually intended to vote in the referendum of the Swiss energy act took part in the study. The study was based on a 2 (argument direction: in favour/against energy act) × 2 (argument framing: left-oriented/right-oriented values) between-subjects experimental design.

After a short introduction of the Swiss energy law, participants were presented with a series of actual arguments, either in favour or against the energy act. The arguments were framed in terms of values referring to either left-oriented or right-oriented ideology (e.g., openness to change vs. tradition; harm/care vs. purity, respectively). The arguments were kept as identical as possible between conditions, only varying in the extent to which they emphasized left/right-oriented values (e.g., "*The energy law will have positive impacts on nature. Energy from renewable sources will reduce pollution due to CO_2-emissions and nuclear waste that currently cause harm to the fragile* [*contaminate the purity of*] *Swiss nature"*). Afterwards, participants reported the extent to which they evaluate the energy law as 1 – *negative* or 8 – *positive* as well as the extent to which they are 1 – *against* or 8 – *in favour* or the energy act. The composite score of both variables served as the dependent variable (α = .863, attitudes toward energy act).

3. RESULTS

In order to test our hypotheses, we conducted a multivariate regression analysis with political orientation, argument direction, and argument framing as well as the respective interaction terms as independent variables. Attitudes toward the energy act served as the dependent variable. Findings revealed that political orientation strongly influenced voting decisions in that left-oriented voters were more likely to vote in favour of the energy act than right-oriented voters (b = -.21, t = -6.81, 95% CI [-0.27; -0.15], p < .001). However, in line with our hypothesis, the impact of ideology was subject to the arguments' framing (b = 0.27, t = 2.16, 95% CI [0.24; 0.51], p = .03), showing that arguments were most influential when they were in line with voters' respective political orientation. Specifically, negative arguments weighted heavier for left-oriented voters when the arguments were framed in terms of values referring to left-oriented ideology (b = -0.11, t = -1.71, 95% CI [-0.24; 0.02], p = .09), while their approval remained stable when negative arguments referred to right-oriented values (b = -0.29, t = -4.44, 95% CI [-0.41; -0.16], p < .001).

4. DISCUSSION

The present study illustrates how political orientation is deeply grounded in distinct core values. These insights have theoretical value as they provide knowledge about the underlying mechanisms responsible for the continuously intensifying political divide observable across the globe (with regard to the environmental domain see e.g.: [5]). As shown in the present study, the mere framing of an argument can alter decision-making, rendering voters susceptible to following the language of their own political camp.

Moreover, the present findings also provide practical value as they illustrate avenues to tackle the political polarization by adapting political communication. Although framing effects were in particular evident with respect to negative arguments in the present research, findings indicate that the promotion of large-scale energy projects can benefit from adapted political communication. That is, instead of merely focusing on one's specific target group, energy project communication should aim to address the core values endorsed across the whole political spectrum – thus making project acceptance ultimately more likely.

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ENERGY ACTORS' VIEWS ON DEMAND RESPONSE FROM HEAT PUMPS

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Keywords: Qualitative study, Demand response, Heat pumps, Apartment building owners, Balance Responsible Party

1. INTRODUCTION AND RELATED WORK

Demand response (DR) is considered one important element in a future energy system to take better advantage of intermittent renewable energy such as wind and solar. Through DR programs, end customers would be given new means to be active by e.g., peak shaving or shifting energy consumption to off-peak hours and thereby save money [e.g., 5]. A potential target group for DR has so far been households; however, there are several documented barriers to DR in this context [5]. One barrier is the low financial incentive in many countries to shift one's energy consumption, resulting in low interest from households to participate. Another fundamental barrier is how to negotiate flexibility with everyday activities that involve domestic electricity, which are performed to address human needs and thereby much less flexible in time [4]. Instead of *single* households participating in DR programs, research has pointed to an alternative approach [2], which involves aggregating and controlling smaller loads from large pools of apartment buildings, including only electricity *for heating and domestic hot water production* using heat pumps (*not* domestic electricity). This approach is so far mainly unexplored, in particular with regards to considerations from potential future users. In this work, we are therefore exploring drivers and barriers for such an approach through interviewing two groups of stakeholders – *apartment building owners* and *balance responsible parties* (BRPs) – who would likely play important roles in such a set-up in the future, as well as each need to gain value from it [e.g., 1]. The aim is to shed light on real-life thoughts and concerns, and thereby add to the important body of knowledge looking at the socio-technical aspects of DR, including how it is envisioned to fit with different target groups' goals and everyday activities [e.g., 1, 4].

2. INTERVIEW STUDY

In order to explore drivers and barriers to DR based on aggregated and remotely controlled loads from heat pumps in a pool of apartment buildings, we conducted a qualitative study in Sweden involving 12 semi-structured phone interviews with 6 apartment building companies and 6 BRPs. All participants had extensive experience and expertise in their respective area, representing professions like energy and maintenance managers in building companies, and R&D managers and electricity market traders at BRPs. The interviews lasted between 35-120 minutes and were audio-recorded and partially transcribed for analysis. Questions related to the participants' professional everyday work, as well as a "*backcasting*" scenario which served as a probe for asking more concrete questions about DR in the future. The short informal text-based scenario was e-mailed to the participants before each interview. Backcasting is a strategic planning methodology used in e.g., sustainable development in which a desired future goal is identified along with necessary steps to reach the future goal [3]. This scenario described a future situation where aggregated flexibility from hundreds of apartment buildings using heat pumps is already possible and provides benefit to stakeholders. As envisioned, a third-party aggregator would manage loads and remotely control the heat-pumps based on some incentives. We did not ask the participants to *systematically* analyze all needed steps, but to reflect on questions connected to the scenario, covering e.g., investments and incentives, imagined flexibility, and views on real-time data sharing. The analysis identified emerging themes in the data, for both groups respectively, as well as across the two groups.

3. FINDINGS

The study provides insights into preconditions, challenges, and values that are key to these participants and which impact both opinions about and current possibilities to participate in DR programs of the kind envisioned in this work. Further, the study sheds light on *areas of potential conflict* between these two groups of stakeholders, which suggests a need for further studies that look at these areas in more depth. For example, both building owners and BRPs stress that they would need real-time access and control of data about the heating in buildings to do their *respective* work correctly (e.g., securing tenants' thermal comfort vs. trading). Without control or insights into the heating situation, building owners are concerned about how to stay accountable to tenants. BRPs argue that they need access to as detailed and reliable real-time data as possible about potential flexibility in order to plan and trade on the market. Next, envisioning different qualities of flexibility pointed to inherent mismatches between the predictability of tenants' everyday patterns and thus needs for heating, and the unpredictability of intermittent renewable energy and thus needs to balance the market. While the apartment building owners imagined that they could be flexible with heating – and estimated this to be a maximum of a few hours per day – the BRPs made it clear that they cannot say in advance how much flexibility they need and when. This is dependent on weather conditions, both current (e.g., solar and wind conditions over several days, weeks or seasons) and future (e.g., climate change impacts), which are very complex to predict and plan for.

4. FINAL CONSIDERATIONS AND CONCLUSIONS

Among others, the following main conclusions will be presented in more detail at the conference:

- There seems to be a fundamental tension between the need for flexibility in the system and the available flexibility from apartment buildings, questioning whether even an aggregated load from apartment buildings would help imbalance at a system level.
- The study suggests there are potential conflicts and tensions about how real-time data is handled and negotiated between involved stakeholders and provides illustrative examples from real life of how this might impact the groups respectively.

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LOW CARBON ADVISORS AND SMES: CHANGING ENERGY BEHAVIOURS THROUGH VALUES-BASED ENGAGEMENTS

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1. BACKGROUND

Small and medium sized enterprises (SMEs) make up 99% of all businesses worldwide and are responsible for 13% of energy demand [1]. There is significant potential for SMEs to reduce their energy consumption and associated emissions. For instance, 18-25% energy savings can typically be made through efficiency measures, up to 37% of which require no capital investment [2]. However, take up of these cost-effective opportunities is low. Research has shown that owner-managers often perceive their businesses to have little impact on the environment, and consider pro-environmental actions expensive [3]. Drivers such as corporate social responsibility (CSR) and environmental legislation have been shown to be less motivating for SMEs than larger enterprises [4,5].

SME groups are typically resistant to conventional ‘hard levers’ such as tax and regulation [6], and the favoured approach to low carbon policy for SMEs is based on providing incentives such as grant funding and face-to-face support in order to foster behavioural change. Publicly funded low carbon advisors are important intermediaries, providing impartial advice and encouraging the uptake of low carbon technologies and practices by SMEs. Research on decision making in SMEs has found a link between the pro-environmental behaviours such as investing in energy efficiency and the values and preferences of owner-managers [7,8]. While low carbon advisors often have strong pro-environmental values, evidence finds they suppress them when talking to their SME clients, and would welcome ideas on how to engage in more productive, values-based interactions.

2. EMPIRICAL APPROACH

This paper reports findings from ‘Growing Greener’ [9]; a multi-disciplinary project aimed at equipping intermediaries with the skills and capabilities to incorporate values-based discussions into their interactions with SMEs. This builds on the ‘Growing Green’ project, which included a set of workshops inviting SMEs to discuss themes relating to business growth and environmental responsibility. This project developed and trialled a method of ‘narrative workshops’, engaging SMEs with peer-to-peer conversations about environment and sustainable growth. This new approach to engaging SMEs, developed by project partners and climate change communication specialists Climate Outreach proved to offer value to participants and to have potential for further development.

Building on the success of the first ‘Growing Green’ project, the narrative workshop method will be applied in a series of workshops targeting low carbon advisors across the UK. Advisors will share experiences of engaging SMEs, and hear academic perspectives from applied psychology and sociology. An Environmental Engagement Toolkit will be produced as an outcome of the workshops, with the aim of enabling intermediaries to engage with SMEs beyond a narrow, cost-benefit framework, and help SME owners and managers to connect low carbon choices with the personal and business values that are important to them as individuals.

Improving the intermediaries' effectiveness will have direct environmental benefits by encouraging more rapid adoption of pro-environmental technologies and practices amongst their SME client base. Developing new ways of engaging SMEs with low carbon policy is particularly timely given the UK government's new Clean Growth Strategy, which sets as a priority engaging with stakeholders on how to improve the provision of information and advice to SMEs so that they take up energy efficiency measures.

3. ANTICIPATED FINDINGS

At the time of submission of this abstract, the field work is yet to be completed so we cannot yet provide findings. However, at the BEHAVE conference we will present findings from workshops with low carbon advisors. We will include a detailed description of the workshop process, evaluation of how effective workshop participants and the research team felt the workshops were, improvements in workshop design through experience and the effects of the workshop on the low carbon advisors and through them on their SME clients.

Our presentation will include extracts from the Environmental Engagement Toolkit, and reflections on the costs, benefits and barriers faced when attempting to integrate value-based discussions between low carbon advisors and SMEs into normal working practices. Although the project is based on the provision of low carbon advice in the United Kingdom, our presentation will discuss the international implications of Growing Greener, and its potential to be reproduced elsewhere.

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CHANGING ENERGY CONSUMPTION BEHAVIOR IN OFFICE BUILDINGS USING ENERGY METER DATA

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Keywords: energy behaviour, office building, feedback, energy meter data

1. INTRODUCTION

Researchers argue that realizing smart buildings is not effective unless the behaviour of the consumers is changed for energy conservation [1]. The implementation of smart grid can provide consumers with their energy consumption pattern. Consumers can learn and adjust their behaviour to reduce consumption. However, the majority of studies have been focused on the residential buildings and small scale energy users. Currently, the existing office buildings account for a significant part of energy consumption of the built environment. This situation gives rise to a discussion regarding how to motivate workers in office buildings to save energy by using energy meter data. This study aims to investigate the possibilities of reducing energy consumption in an office-type workplace by bringing changes in the energy consumption behaviour of workers using their energy meter data as feedback. To get this insight, first the literature on already existing studies related to energy consumption feedback are summarised and factors related to using energy consumption feedback to realize behaviour change are explored. Then, a state choice experiment is conducted to find the preferred approach of office workers when they are provided feedback on the basis of energy meter data.

2. METHODOLOGY

Firstly, a literature review has been conducted. It reveals various factors related to the potentials of using energy consumption feedback to realize pro-environmental behaviour of consumers in addition to personal characteristics both in office building and in residential buildings. However, household consumers pay their own energy bills whereas in office buildings the organizations pay bills which results into a lower motivation to save energy among workers [2]. Main aspects responsible for bringing out change in energy consumption behaviour with feedback observed from literature are categorized as feedback characteristics, social interaction factors, and gamification factors [3][4][5]. Feedback characteristics related to data disaggregation i.e. feedback type (appliance level information or overall information) and feedback period (daily, weekly, monthly or real time). Social interaction factors involve comparison i.e. comparison with different groups (teams within the office or outside the office) and company's average, and information display i.e. providing feedback on private or public displays. Gamification consists of factors goal setting i.e. receiving target on energy saving (yes or no), and competition with added feature of receiving reward if target is achieved (yes or no). Considering all these factors, a conceptual model is set up to research the preference of workers related to using energy consumption data to get motivated to save energy in office environment.

Next, a state choice experiment [6] is developed based on the identified six factors of which three consists of two levels, one with four levels and one with three levels. With the attributes and corresponding levels 16 alternatives are generated using fractional factorial design. Each alternative presents a hypothetical situation with the factors describing how the feedback is provided. The alternatives are included in eight choice tasks, each consisting of two alternatives and a 'None-of-these' alternative. 193 respondents completed the on-line questionnaire. The respondents live across the Netherlands and were approached through social media.

3. PRIMARY RESULTS AND DISCUSSION

The respondents evaluated 1544 choice tasks. The evaluations are analysed using a standard multinomial logit (MNL) model. The estimated model outperforms the model in which all parameters are equal to zero. It appears that not all attributes are significant. The attributes with the highest preference are from the gamification category, namely competition followed by goal setting, which shows that receiving reward on achieving target of energy saving motivates more to save energy than just receiving target. Next important attribute is receiving feedback information on public displays i.e. creating peer pressure when own data is visible to others. Appliance level feedback and comparison among teams inside office are identified as next important factors with coefficients significant and almost similar effects. However, the feedback period with levels daily, weekly, monthly, or real time did not show any significant direct result, which suggests that the time period of receiving feedback works may better when combined with other significant factors.

In addition, estimations of MNL models taking into account different sample groups showed the difference in opinion of respondents being experienced and unexperienced in energy saving program. In addition, random parameter logit model showed that the preferences of respondents are highly heterogeneous, meaning they vary from each other, which confirms human behaviour varies from person to person.

From the results, it is perceived that the factors that encourage social-interaction such as gamification, public displays, comparison, and disaggregation of data on appliance level are significantly influential in energy saving than the time period for which the data is made available. Since receiving feedback at different time periods is argued to have potential in energy saving [7], researching this attribute separately is suggested. With the estimated parameters a preference based tool can be built to identify the most suitable strategy to motivate office workers to change energy consumption behavior in office buildings using the energy meter data.

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The effect of personal energy advice on households' energy use A randomized controlled field experiment

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Keywords: energy advisor, energy consumption behavior, field experiment, habits, routines

1. INTRODUCTION

Measures for reducing households' energy use can be categorized as addressing efficiency behaviors and/or habitual behaviors, which are also described as 'curtailment' or 'sufficiency' behaviors [1–3]. There are at least three reasons why it is important to put more emphasize on the latter type of behavior as is currently done in empirical research. Firstly, everyone can be addressed; especially also tentnants who usually have less possibilities than landlords for undertaking energy efficiency investments. Secondly, a large amount of behaviors can be categorized as habitual [4]. Thirdly, habitual behaviors are extremely difficult to change [5]. Regarding energy saving, the literature suggests that tailored advice (i.e. information and feedback) and personal contact helps households to understand their energy consumption and to engage in meaningful actions to reduce it [6]. An intervention that combines these features (i.e., tailored advice and personal contact) is tailored energy advice. It has been shown that energy advice is less effective in promoting changes in habitual behaviors, compared to energy efficiency behaviors [see for example 7,8], but these studies have some methodological shortcomings. Firstly, participants were often asked retrospectively about their behavior. Hence, results may be biased due to social desirability and/or memory gaps. Secondly, in most studies known to us, there was no control group, therefore, it is difficult to estimate the impact that is due to the energy advice. To our knowledge, there is only one study that tested the impact of energy advice in a randomized controlled field experiment [9]. However, in this study, energy advice did not take place in people's home but in the customer service centre of the cantonal electricity provider. One finding was, that people who received energy advice found it easier to install energy saving measures and perform behaviors, although, this did not result in actual energy savings. In order to overcome implementation barriers, the authors suggest that people should also be advised on the implementation of energy saving behaviors as part of the energy consultation [9]. This is the point which our study takes up. We assume that implementation barriers can best be addressed when people are visited in their homes and when advice on energy saving is given on the spot.

2. PROCEDURE

In order to assess the impact of personal energy advice on households's energy consumption, we designed a randomized controlled field experiment. The field experiment is envisaged to run from March to April 2018. Recruitement was via invitation letters to 1000 randomly selected households of the Canton of Basel-Stadt in February 2018.[i] As compensation, households were promised a selection of energy-saving items after study completion. In total 161 households agreed to participate, 17 of which did not provide an e-mail address and were thus excluded from the study due to the fact that the accompanying surveys will be online. Therefore, 144 households were randomly assigned to the treatment or control group. All participants were asked to fill in a pre-, 4-week post- and a 6-months follow-up online survey. The survey includes questions about demographic information, current meter readings and yearly spending information on electricity, heating and warm water consumption, as well as information on specific behaviors for habitual energy consumption such as stand-by, washing, drying, cooking, and heating. In the next step, all households from the treatment group, that have answered the baseline survey, will receive a tailored energy advice in their homes. Young adults were trained from the cantonal energy advisor (Amt für Umwelt & Energie, Basel-Stadt) in a one day workshop and tested the consultation process with test households. We will follow a difference-in-difference estimation strategy to estimate the effect of energy advice on habitual energy consumption.

3. RESULTS AND CONCLUSIONS

Results will provide an estimate on the effect of energy advice in households for changing habitual energy consumption behavior. Furthermore, analyses will shed light on the mechanisms through which habitual energy consumption behavior might change, such as changes in social and personal norms, attitudes, and the degree of automaticity of habits. The results will be relevant for the design and implementation of interventions for changing habitual energy consumption.

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AGENT-BASED MODEL OF ENERGY EFFICIENCY TECHNOLOGY ADOPTION IN HOUSEHOLDS - A FIRST VERSION WITH POLICIES TARGETED AT INTERMEDIARIES

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Keywords: Energy efficiency, Agent-based modelling, Households, Policy support, Intermediaries

1. INTRODUCTION

The model discussed in this abstract is a first version of an agent-based model (ABM) aimed at describing the adoption of a variety of household appliances. Currently washing machines, fridges and televisions are modelled. These technologies are modelled because our literature study on energy efficiency adoption ABMs [1] indicates that they have not been modelled before using ABM. Another important conclusion from this review is that the models focus on conventional policies such as subsidies, technology bans and information campaigns. We therefore see a opportunity to explore novel policy alternatives that include intermediary parties in residential energy efficiency adoption. This first version of the model is used to compare different policies that include intermediary parties and will be expanded in order to provide specific policy advice for a variety of household energy technologies.

2. METHOD: AGENT-BASED MODELLING

Households and energy technologies The model contains two types of agents: households and intermediaries. Households own of an energy technology, e.g. a washing machine. Over a period of thirty years (i.e. 30 time steps) households make use of their technology and interact with friends. The households in the model are embedded in a social network and share attitudes and preferences regarding energy efficient technologies. Over time, different reasons for households may emerge to adopt a new energy technology. The technology may break down prematurely, the household may decide to replace it, and the expected lifetime of the technology may run out. When a household decides to replace his energy technology, he decides 1) where to get this technology and 2) which replacement he prefers. The logic to do this is rooted in the theory of planned behaviour [2]: in their decision, their attitude, subjective norm and perceived behavioural control lead to certain intentions (modelled as thresholds), which are needed to perform particular adoption behaviour.

The market Households have two options to replace technologies: in the market or with an intermediary. From the technologies available in the market, households pre-select between 3 to 8 technologies. Technologies may differ in size, volume, capacity, energy label, electricity usage, and aesthetic quality. The household picks its new energy technology according to how well his preferences and attitudes match the characteristics of the technologies in the pre-selected set.

The intermediary The alternative is to purchase a technology from an intermediary party. Intermediaries are modelled to only sell the most efficient technologies available (technologies with an A++ or A+++ energy label). Intermediaries aim to acquire more customers by advertising to households and influencing their preferences and attitudes towards energy efficiency and this role of intermediaries in the market for appliances. When intermediary-oriented policies are in place, intermediaries earn extra income when realizing energy efficiency improvements in households.

Energy efficiency policies Two intermediary-oriented policies are modelled: an energy efficiency tender and tradable white certificates. When an energy efficiency tender is in place, intermediaries bid for an amount of efficiency improvements they aim to realize at a particular price. When they win the bid, they receive an income to be used as advertising budget or as profit. Tradable white certificates are awarded when realizing efficiency improvement. Intermediaries can sell these certificates for the exogenous market price. Other policies modelled are a subsidy and minimum performance standard.

3. FIRST RESULTS AND OUTLOOK

First experiment The model has been run to compare the effects of the different policies. A first experiment was done to see the effect of indirect policies (energy efficiency tender and tradable white certificates) on the adoption of washing machines by households. Over time both policies increases the adoption of A++ and A+++ significantly (compared to a case with no policies). This indicates that the intermediary can be successful in increasing energy efficiency adoption. The size of the effect appears to be comparable to that of a minimum performance standard.

Outlook We have the objective to be able to provide insight in which energy efficiency policies perform well under a variety of circumstances and types of appliances. In order to achieve this objective, our next steps are to 1) incorporate results from a large survey with preferences and choices of households, 2) add more data on intermediaries to improve their modelled behaviour, 3) revisit the model decision logic on the basis of survey details, and 4) to add more appliance technologies and energy efficiency policies.

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HOW TO MOTIVATE PEOPLE TO EAT MORE ENVIRONMENTAL FRIENDLY? AN INTERVENTION STUDY THAT INVESTIGATES ALSO ON UNCONCIOUSE PROCESSES

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Keywords: Food choices, Sustainability, environmental friendly alimentation, unconscious processes, intervention study

Background: Our daily food choices have a huge impact on the environment. Greenhouse gas emissions (GHG) as well as water consumption and land use are highly influenced by our daily food consumption. In Switzerland it adds up to almost 30% of the damage to the environment, regarding to the Federal Office for the Environment [1]. A model to explain sustainable alimentation states that five dimensions, environment, economy, society, individual/health and culture have to be taken into account [2]. Deduced from this model seven objectives that should lead to a more "future-friendly" alimentation have been developed [2]. The objectives are listed anticlimactic of their potential savings for greenhouse gas emissions: 1) preference of plant based foods, 2) ecologically produced foods, 3) regional and seasonal produce, 4) preference of non-processed foods, 5) fair trade produce, 6) conservative way of economising with resources, 7) enjoyment and digestibility of foods [2].

Theoretical Assumptions: Motivational psychology provides explanatory models for voluntary behavioural change such as the model of action phases [3]. Based on this model the 'Stage Model of Self-Regulated Behavioural Change' (SSBC) was developed, which can be used as a groundwork on the development of systematic interventions [4]. It also describes seven types of interventions that can influence a persons motivation. Both models (model of action phases [3] and SSBC [4]) start with a conscious 'predecisional stage'. Grawe [5] points out that lots of desires and needs that lead to motives are not yet conscious and suggested that the model of action phases [3] should be enhanced.

Research Question (IV & DV): Is it possible to motivate people to eat more environmentally friendly via an online intervention? The hypothesis is, that people that are willing to change their alimentation behaviour, can be motivated by this intervention. The seven objects that have been described in the model of sustainable alimentation [2], will be measured and turned into an alimentation-environmental-friendliness-score (AEFS) as a dependent variable (DV). Five types of interventions [4] will be included in the survey such as: making social norms salient by giving feedback (intervention type: IT1), raising problem awareness by providing information about the impact of the food choices (IT2), promoting goal setting and goal commitment (IT3), providing information about the possible action (IT4) and supporting behavioural planning (IT7) with the method of 'if then planning' [6]. These interventions are considered as independent variables (IV).

The stages according the SSBC will be assessed as co-variates, so are personal data such as age, gender, education, domicile, main activity and personality indicators such as big 5 [7] and self-efficacy [8]. What is the unconscious attitude towards environmental friendly alimentation? This exploratory research question will be answered by measuring the implicit attitude of the participants as a co-variate.

Method and Data Analysis: A intervention designed as an online survey has been developed and tested beforehand. The pre-post experiment takes place from May (T1) to June (T2), with two follow-up investigations in July (T3) and August 2018 (T4). Participants receive the link to the survey via e-mail or QR-code-flyer. Many different institutions are contacted to avoid that only people with high environmental friendliness are participating. The survey is designed in two parts. All participants will fill out the first part, that includes personal data, the stages of SSBC and the AEFS-questionnaire. At the end of part one, participants are asked if they would like to eat more environmental friendly. Only participants that answer with 'yes' will be randomly assigned to either control group, the test group one (G1) or two (G2) for the second part. All groups will be informed about the further enquiries. Participants that answer with "no" will be provided with IT1 and IT2. After they are asked again if they want to change their eating habits. If they answer with 'yes', they will be provided with the same information as G1. At T2, the stages of SSBC, AEFS-questionnaire, personality indicators and an implicit association test (IAT) is provided to all participants. At T3 and T4 the stages of SSBC, AEFS-questionnaire are assessed. To analyse the data a generalized estimating equation (GEE) will be applied.

Results: In May 1099 participants completed the first part of the survey. With 314 participants completing the second part of the survey in one of the test groups, the power of this study should be significant. The second survey is now on-going and the final results will be available in September 18.

Discussion: There is no official scientific definition on environmental friendly alimentation or sustainable alimentation yet. Voluntary behavioural change may only motivate people that already have environmentally friendly habits. Anyhow this study could indicate, that already this small intervention can have an impact on daily food choices.

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GATHERING LEARNINGS FROM A BEHAVIORAL METHODOLOGY AIMED AT RIO DE JANEIRO LOW INCOME COMMUNITIES WITH HIGH INCIDENCE OF ENERGY COMMERCIAL LOSSES

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Keywords: Behaviour, Brazilian Low-income communities, Commercial Losses, Energy Efficiency, Real-Time Feedback.

INTRODUCTION

Energy waste, not different from any other kind of irregular consumption, hold a myriad of specificities, which may vary from what is being consumed by the public and the environmental conditions in which the consumption is taking place. Moreover, idiosyncrasies must be also taken into account; understanding how irregular energy consumption works can be as challenging as to meet right tools to address the matter, and so to achieve effective solutions. Such solutions, moreover, rely on a broad range of variables to be met, for example; understanding the local regulation for energy distribution and consumption, the macroeconomics variables (income, employment, education level, etc.), all of them combined with awareness of the locals related to life risks involved in such acts and the pros and cons of consuming energy irregularly, as a regularization program was in progress by the local utility. These factors resulted in an intervention program over low-income households in Rio de Janeiro city, using feedback tools to educate locals into a change on their behaviours related on how they consume energy.

LITERATURE REVIEW

According to Pegels, Figueroa and Never (2015) [1] feedback actions has been proven effective to reduce consumption from 0.3 to 6.3% in energy bills. Thus, the engagement needs to be attractive, not necessarily financial, but rather combine with social norms and attitudes. Embedded good practices tends to spread organically, making the participants themselves as multipliers. Regarding the comprehension on the consumption over irregular energy use, it is necessary to understand how people engage on this kind of behaviour, taking in consideration that the locals are fully aware of their acts.
According to Yaccoub (2011) [2] low income residents living in Rio de Janeiro communities tend to associate the capacity of purchasing power as a way of social inclusion and the upcoming technologies is expected to become a new problem as these products are energy-demanders, plus the fact they live with a limited income. These factors create a barrier between their will to consume with their ability to pay for their energy bills[i].

METHODS

As part of these efforts, a behavioural program was engaged to low income communities located in

[i] This project is aligned with the Sustainable Development Goals, specifically numbers 7 – Affordable and clean energy and 12 – Responsible Consumption and Production.

Rio de Janeiro city, with the objective to transition these customers from the irregularity to regularity. They were approached with real time feedback tools [3], pamphlets and awareness as ways to engage them in a more sustainable and efficient energy consumption behaviour. The chosen approach consisted in simulate their current consumption behaviours and then compare with a more efficient one, displaying the total money amounted spent per month, accumulated in one, five and 10 years, these based mainly in home appliances using time and their efficiency official standards. The IT simulation assembled a "behavioural plan", which was printed and delivered to customers to take home, easing them to adopt new habits and behaviours.

RESULTS

Preliminary trends analysis indicates that the treated group (approached with the behavioural program) as more resilient to consumption seasonal increase than the non-treated group, thus having decelerated their consumption increase inherent to market seasonality. Results of the program show around 10% of decreasing. This analysis confirms the previous achievements from Pegels et al. (2015) [1], towards the understanding of how feedback can engage customers to spend less on their energy bills - even among customers who weren't used to pay for the energy they consumed.

CONCLUSIONS

This case also has indicated how behavioural tools may be engaged to mitigate a recurrent issue to the Brazilian power utilities, the market and the society. This experiment suggests that energy efficiency programs can achieve better results as long as they are able to keep connected with the treated population. This capability brought together with standardized actions (applying in households as the ones applied to schools) can drive to a new prospect for investments in energy efficiency programs.

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EVALUTION OF INTERVENTIONS IMPLEMENTED BY RESCOOPS TO STIMULATE HOUSEHOLD ENERGY CONSERVATION; RESULTS FROM A SURVEY IN SIX EU COUNTRIES

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Keywords: Renewable energy supplying cooperative; energy conservation; community energy; policy instrument; incentive; energy consumption.

1. ABSTRACT

In recent years cooperatives for renewable energy supply (REScoops) have emerged as important new actors in energy markets. They provide their members (i.e., households) with renewably generated energy within a cooperative model that enables members to co-decide on its strategic and tactical goals, plans and business model. REScoops do not only collectively own renewable energy production facilities and supply this to their members. They also use their specific position as energy suppliers to take several actions to persuade their members (households) to engage in energy conservation. Because of their particular organisational and business model as citizens' initiatives REScoops are in theory well positioned for activities to influence and help their members conserve energy. This particularly has to do with REScoops being in close proximity of their members, which enables them to intervene and influence social structures and social norms. In a previous paper by the authors arguments were presented why and how REScoops do this, presenting a number of policy measures they engage in to persuade their members to conserve energy. Moreover, a number of measures were discussed that have actually been undertaken by REScoops [1]. Although this study disclosed information on the aims, the working mechanism ('policy theory'), the scope of, and a few experiences with these measures it revealed little about their impact in terms of household energy savings.

In this paper we tap into this issue and pay attention to the evaluation of a number of measures implemented by REScoops. The main research question therefore is how the implementation of selected policy measures by REScoops is experienced by REScoop members, and whether these measures contribute to (self-) reported household energy savings? The measures that will be assessed in this study include both antecedent strategies (i.e. information, awareness making campaigns,

workshops, tailored advice[i]), consequence strategies (i.e. online platform with feedback on energy consumption, billing[ii]) and combinations of those (i.e. integrated, 'package approaches'[iii]).
The research of this paper is based on a a survey conducted in the period of March-July 2018, among seven REScoops in six EU nations; i.e. Coopérnico (Portugal), Enostra (Italy), Ecopower (Belgium), Enercoop (France), EBO (Denmark), SEV (Southern Tyrol, Italy) and SOM energia (Spain). It comprises one of the few quantitative studies on REScoops in particular and community energy in general, and is thus far the only one that analyses assesses REScoop interventions, in particular on their influence on household energy conservation behaviour.

The analysis of survey data uses a 'modus operandi' approach to reveal evidence vis-à-vis the claim that the measures implemented explain for (self-reported) energy savings among households, and counter evidence to alternative explanations. Following this approach a number ways to assess the impact of the measures implemented by REScoops on energy consumption behaviour by households will be conducted; i.e., energy saving actions undertaken by households, and (self-reported) energy savings among households comparing between experiment and control groups (using independent sample T-tests). In addition, data on perceived contribution of the measure to (self-reported) energy savings, and satisfaction with the measure will be analysed. We also analyse the statistical relation between psychological variables, demographics and household energy conservation (using correlation coefficients analysis). Next to the quantitative analysis of the survey data qualitative insights regarding the implementation of selected REScoop measures will be collected and analysed. Following this triangulation of data we judge whether policy measures implemented by REScoops can be deemed effective interventions to stimulate household energy conservation.[iv]

This paper contributes to (a) the growing body of literature on REScoops as emerging actors in the energy domain, (b) to the growing body of literature of social innovation (i.e., social intervention) in energy transitions, and (c) to the body of literature in environmental psychology that studies the impact of different types of intervention strategies on household energy consumption and conservation [2].
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[i] i.e. 'Energy savings wiki'; newsletters; 'TupperWatt' meetings; leaflets.
[ii] i.e. 'Energie ID'; 'Infoenergeia'.
[iii] i.e. 'Dr. Watt'; 'Package approach district heating'.
[iv] On the moment of writing of this abstract no (preliminary) results can yet be presented as data are still in the process of being collected.

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CODE OFFICIALS IN INDIA: EXTENDING THE AGENCY & CAPACITY OF BUILDING REGULATORS

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Keywords: middle actors, code officials, middle-out perspective, concern, capacity, conditions

1. INTRODUCTION

Between now and 2030, extraordinary growth in new construction in India will shape the country's long-term energy use by locking-in or blocking-out low carbon buildings. Enacted in 2007, India's Energy Conservation Building Code (ECBC) is the primary regulatory instrument designed to achieve energy efficiency in new construction.

Energy codes must be implemented to be effective, however, and to be fully effective in India this requires formal adoption by 35 different Indian states and territories. In the last 10 years, only seven Indian states have formally adopted the ECBC, and almost none see widespread compliance. In response, state-level "ECBC Cells" are being set up and supported by international aid agencies to coordinate code adoption and build capacity for implementation. Since 2015, three ECBC cells are functional and four more are underway.

This paper focuses on the development and operation of these ECBC cells, recognizing the importance of code officials and their institutions as essential "middle actors"[1, 2] in managing the energy transition in India's building stock. It recognizes that "code officials are people, too" and seeks socio-technical ways to support their work practices.

2. APPROACH

Studies of building codes often include a best case "technical potential" scenario. Technical potential is based on engineering and economic calculations that are performed without concern for the probability of successful implementation [3]. The code implementation literature, on the other hand, recognizes the need for stakeholder engagement, compliance infrastructure, and education. This study draws on the code implementation literature from India [4-7], the U.S. [8] and Europe [9] to extend a case study based in Karnataka, which is considered to be a "best case" scenario for India. In line with emerging literature, this paper views the built environment as a dynamic, evolving system where the interrelationship between policy, technology and humans is critical to success [10].

3. METHODS & ANALYSIS

The case study is based on both secondary research (document review) and primary research (interviews with key experts). We apply a 4Cs framework (concern, capacity, and conditions within a community)[11, 12] to reveal the social, technical, and institutional complexities of Indian energy code implementation. The 4Cs framework proposes that energy efficiency and conservation actions depend on the level of "concern" about efficiency relative to other goals; the "capacity" to take action; and the real-world physical and technical "conditions" of the premises that are to be acted upon. The "community" variable crosscuts the other factors, addressing human factors across individual, organizational, and policy dimensions.

4. FINDINGS

We find that concern, capacity, and conditions for following energy codes are all limited by the agency and capacity of code officials at the local level. Creating a ongoing, multi-level code community could help develop and grow this scarce social capital. Based on the literature and fieldwork, we argue that constructing social and professional networks within and between Indian states will deliver greater results of code compliance than top-down promlugation alone. We recommend providing more opportunities for ECBC cells to work *sideways* to share knowledge across state boundaries, as state-level energy code officials do in the United States. ECBC cells are also ideally suited to share experience *downstream* to cities, where the implementation and enforcement of the code needs to happen regularly at a local level. These ECBC knowledge networks are essential for India to seize a narrow window of opportunity to lock-in low-carbon construction practices across one of the world's most rapidly urbanizing and populous countries.

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EXPLAINING THE ENERGY PERFORMANCE GAP IN PROFESSIONALLY MANAGED BUILDINGS

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Keywords: Energy Performance Gap, Real Estate Management, Procurement, Business Models, Behaviour Change

1. INTRODUCTION AND THEORETICAL BACKGROUND

Existing buildings cause around 40% of European energy consumption and 36% of European CO_2 emissions [1]. The current state of knowledge and technology would allow for using, operating, and retrofitting these buildings in a way that drastically decreases the use of operating and grey energy and greatly increases utilization of renewable energy. However, despite the growing diffusion, number and intensity of governmental regulations, incentives and support programmes which aim for realizing these potentials, most buildings continue to use much more operational and grey energy than necessary [2] and to rely mainly on fossil fuels for heating, cooling, air conditioning, ventilation, domestic hot water and electricity supply [1]. The question is raised why the involved actors are not willing or able to change this situation. Previous research on the topic has been conducted under the heading of the so-called energy-performance gap. Researchers in this area have shown that buildings in operation often use much more energy than initially predicted by building planners [2]. Typically, the following factor categories causing the energy performance gap have been identified: Suboptimal planning or energy consumption simulation (e.g. suboptimal integration of technical components), construction not as planned (e.g. insulation to thin), operation not as planned (e.g. simultaneous heating and cooling) and inappropriate user behaviour (e.g. windows constantly opened at high or low outdoor temperatures) [e.g. 2]. Although such explanations of unexpected building energy consumption are not wrong, they are not very helpful either: 1. The energy performance gap as defined in previous research refers only to consumption of operating energy. However, when evaluating a building's climate impact (overall energy performance), the use of grey and renewable energy certainly needs to be considered. 2. Focusing on the differences between planned and predicted energy consumption distracts from the fact that there is another and probably even larger part of the energy performance gap: the gap between ideal (technically feasible) and planned energy consumption. Considering this gap reveals that building-owners are key actors for building (energy) performance throughout the building life cycle. They are the ones who decide on expenditures for and goals of building operation processes and retrofit projects. 3. The often one-sided focus on technical causes of the energy performance gap neglects that all technical objects and conditions are created over time by human decisions and actions. Human decisions and actions, in turn, are never taken in isolation [3]. Instead, they are often embedded in complex and context-dependent social and organizational systems. The author of this abstract hypothesizes that an appropriate understanding of our building's energy performance gaps is only feasible if we retrace and describe holistically how motives and actions of all relevant actors interact with each-other and with energy-relevant building elements and conditions to produce the observed outcome (socio-technical approach [3]). The research reported here aims at providing such a description for professionally managed buildings in Switzerland.

3. METHOD

Literature search, interviews and documents analysis were triangulated to understand better what barriers to ideal energy performance are experienced by different actors when highly energy-relevant building elements (building-technology and envelope) are operated (operation, optimization, inspection, maintenance, repair) or changed (replacement, retrofit, upgrade). Both, the perspectives and dependencies of actors of building-owner organizations and service provider organizations were studied and described. 19 actors with the following job roles were interviewed (number of interviews indicated in brackets): Asset managers (1), facility managers (3), providers of optimization, inspection, maintenance and repair services (3), construction project managers (2), planners (6) and installers (3) of building technology, sustainability advisors (1). Documents provided by the interviewees (organization charts, strategies, contracts etc.) were used to complement the analysis.

3. RESULTS AND DISCUSSION

For lack of space only a very simplified description of the socio-technical system that causes the energy performance gap in professionally managed buildings can be provided here: Actors of *building-owners* (e.g. portfolio, asset, construction project and facility managers) rarely define energy-optimization as an important strategic, project or process goal since the benefits (or at least the harmlessness) of such measures for the core business (e.g. operation reliability, occupant comfort, cutting expenditures, rent return) are either intransparent, small or inexistent. Hence, building-owner organizations' internal real estate management and procurement of real estate services (regarding budgeting, tendering, contracts, key performance indicators, remuneration and controlling) focus one-sidedly on the obvious needs of the core business without considering that a joint optimization of energy and core business might be feasible. Additionally, this status quo is preserved by powerful and long-established professional norms and practices. The consequences of such practices for *service providers* are manifold. Typical examples pertaining to *building operation* include: (1) Providers of integrated facility management avoid submitting tenders that budget operation optimization appropriately since this increases the risk of not being awarded the contract; (2) Operation optimizations conducted by external specialists are often reversed by building operators because they are incentivized to respond to every single occupant complaint. Typical examples pertaining to *construction projects* include: (1) Sustainable solutions are evaluated but are discarded first when it comes to cost-cutting; (2) Offers for integrated project delivery are not made by planners and installers, since this wouldn't match the building-owner's tendering practices; (3) Before handing over the technical facilities to the operator, none of the planners and installers has the mandate, budget and responsibility or pressure for integrated testing, commissioning, documentation and instruction. Based on the system analysis above, the author of this abstract argues that the building-related energy-performance gap could be removed if real estate service providers started to develop business-models that jointly and evidentially optimize the building-owner's core business and building energy performance. However, such business models might only be successful if building owners innovate and professionalize their procurement practices and share risks and profits with the service provider.

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CHALLENGING COMMON ASSUMPTIONS OF OCCUPANT BEHAVIOUR TO MITIGATE OVERHEATING OR POOR INDOOR AIR QUALITY

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Keywords: Ventilation, Overheating, Behaviour, Indoor air quality, Modelling, Case Study

1. INTRODUCTION

Attempts to quantify future energy savings and associated benefits of energy efficient retrofit to the UK housing stock rely heavily on increasingly sophisticated computer models, often due to a lack of empirical data and uncertainties around future external factors such as climate. These models can predict the effects of different improvements to different housing archetypes under different stressors including different climate scenarios (e.g. EnergyPlus). Whilst many of the inputs to these models are based on fundamental principles of thermodynamics and building physics, the nature of a home is that it is occupied by people and, thus, models need to integrate assumptions around occupant behaviour [1].

While some progress has been made in understanding the impact of occupant behaviour on energy consumption [2] [3], impacts on the internal environment such as air quality and ambient temperature are not well understood, making accurate and reliable model development a challenge [4]. Modellers often rely on logical assumptions around theories of behaviour such as 'adaptive thermal comfort' [2], which assumes that occupants, when faced with a stimulus that provides discomfort, will adapt their behaviour or enact behaviours that should restore comfort [5]. However, such theories of behaviour are based on myriad assumptions themselves, such as occupants being i) aware of optimal behaviours to address discomfort; ii) sensitive to causal links between different behaviours and outcomes and iii) not subject to wider constraints preventing them from acting to restore comfort. Should occupants regularly defy expected behaviour for any such reason, then the conclusions of the models based on the expected behaviour can be called into question. This may further lead to expected benefits of retrofit being overstated and the emergence a range of potential unintended consequences [6] that may lead to disbenefits that impact occupant health, comfort and wellbeing.

2. AIMS & METHODS

This paper reviews the range of assumptions that undergird previous studies in this field and will challenge some of these assumptions by examining case study evidence in the literature and presenting a grounded approach to a case-study of three dwellings. The case study dwellings comprise three flats in South London retrofitted with loft insulation, internal wall insulation, highly efficient windows and doors and mechanical ventilation with heat recovery. Ambient temperature, relative humidity and CO_2 concentration was monitored throughout each property for a three month period in the summer of 2017. Monitoring data was supplemented by qualitative interviews with household members to identify key reported behaviours associated with ventilation and managing overheating.

3. FINDINGS & DISCUSSION

The paper presents evidence from the literature of common modelled assumptions contrasted with case study evidence that show significant deviation from expected behaviours. For example, Mavrogianni, et al (2014) [2] highlights a common assumption used in models that occupants open windows during warm weather but close them when external temperatures rise above a certain threshold (and above internal temperatures) to prevent ingress of warmer air. Evidence from a case study of retrofitted UK flats [7] showed that 30% of participants kept windows open during occupied hours at all times, regardless of the external temperatures. Furthermore, all three dwellings in this study kept windows open throughout daytime hours during the heatwave of June 2017 with no consideration of the internal-external differential. Similar findings are presented for other behaviours including night ventilation and solar shading (where participants exhibit limited take-up of either behaviour). Evidence from the monitored data are also presented to suggest this collection of behaviours might have impacted the internal environment. Initial findings from a follow-up study in winter are provided. Methodological limitations and their impact on interpretation are also discussed.

4. CONCLUSIONS

The paper concludes that there is a mismatch between observed behaviours and expected behaviours such that rather than improving occupants' thermal comfort and reducing risks of concerns such as overheating or poor indoor air quality occupant behaviours sometimes exacerbate the problems. It proposes potential alternative behavioural scenarios that modellers may consider in order to develop models that may better predict risks of issues associated with overheating and poor indoor air quality in simulations of future buildings and future climates. It also identifies opportunities for technological or behavioural interventions to address counter-productive behaviours, such as warning lights or alarms by windows when windows opened to hotter exterior temperatures in summer.

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DYNAMIC INTERVENTION STRATEGIES TO CHANGE ENERGY CONSUMPTION BEHAVIOUR IN RESIDENTIAL BUILDINGS

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Keywords: energy consumption behaviour, household energy consumption, interventions, segmentation

1. INTRODUCTION

Being confronted with the responsibility to contribute to the implementation of energy reduction policies for a sustainable development, utilities face the challenge to develop new business models that allow them to decouple their revenues from selling energy. In the Horizon 2020 project "Utility Business Model Transformation through human-centric behavioural interventions and ICT tools for Energy Efficiency" (UtilitEE), options for utilities to provide energy-related services are elaborated by testing interventions and ICT tools operating with energy-use feedback and automation strategies to induce energy savings.
In the context of this project, we explore dynamic intervention strategies to change energy consumption behaviour in residential buildings in five European countries, focussing on energy use with regard to heating and HVAC as well as electricity. The strategies proposed are a) developed for four groups of consumers and b) aimed at two phases of behavioural change. The dynamic intervention strategies are developed based on findings from the literature on segmentation, interventions and trigger points, as well as phases of behavioural change. They will be exemplarily tested in the pilot sites of the UtilitEE research project: Among others, utilities and residentials have the possibility to formulate feedback on the interventions and ICT tools, which will be integrated into the conception and design of the intervention strategies.

2. DEVELOPING DYNAMIC INTERVENTION STRATEGIES

2.1. Segmentation

Following Bornemann et al. [1] who argue for group-specific governance with regard to changing individual energy consumption behaviour, the diversity of addressees in the context of the UtilitEE research project is taken into account by dividing the residential energy consumers in the pilot areas into groups. The segmentation model used for this purpose distinguishes between four consumer groups along two axes: On one axis, residential consumers are allocated between being rational and intuitive, on the other between proactive and reactive. Based on a questionnaire, the energy consumers taking part in the UtilitEE research project are allocated to these groups. Each of the consumer groups is expected to react differently to specific interventions.

2.2. Interventions and Trigger Points

Drawing on the distinction suggested by Burger et al. [2], we differentiate between trigger points and interventions. Trigger points such as knowledge, emotions, and values are the potentially explaining factors for energy consumption behaviour which can be influenced by interventions. Interventions target one or several trigger points in order to induce and/or sustain change in energy consumption behaviour. In the context of the UtilitEE project, information, feedback interventions (e.g. comparison, goal-setting and reward systems), recommendations, technology-based interventions and confirmation are regarded as relevant types of interventions that may induce and maintain energy consumption behaviour change.

2.3. Phases of Behavioural Change

Bamberg [3] shows that phase-based interventions have a bigger effect on behavioural change than 'traditional' interventions. Taking the phase model used by Bamberg as a starting point, we distinguish between two main phases regarding the change of energy consumption behaviour: First, 'breaking up routines' combines the predecisional phase where actual and habitualized behaviour is re-evaluated and the preactional phase of selecting alternative behaviour [4]. Second, 'setting new routines' combines the actional phase "implementing new behaviour" and the postactional phase "to avoid regressing to old behavioral patterns" [4, p. 41]. In the first phase, behavioural change is induced, shifting from old routines to change. In the second phase, new routines are established, shifting from change to new routines.

3. EXPECTED CONCLUSIONS

As a first conclusion, we expect that multi-dimensional interventions targeting several trigger points have a bigger effect on the change of energy consumption behaviour than interventions that only target one trigger point [1]. Moreover, we anticipate that certain interventions will work better for certain groups of consumers. For example, rational consumers are expected to react more strongly to knowledge-oriented interventions such as information e.g. on the effects of energy consumption on the environment, whereas creative consumers are expected to react more strongly to emotions-oriented interventions such as salience nudges. Also, we assume that reactive consumers prefer automation over taking action themselves, whereas proactive consumers value making their own decisions and changing their behaviour consciously.

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CONSUMERS' BEHAVIOUR TOWARDS THERMAL ENERGY SYSTEMS ADOPTION: FINDINGS FROM THE TESSe2b EUROPEAN PROJECT

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Keywords: ground source heat pump, solar thermal, thermal energy storage, consumer behaviour, socioeconomic characteristics

1. INTRODUCTION

The residential building sector is responsible for a large proportion of the energy consumption worldwide, mainly due to heating, cooling and Domestic Hot Water (DHW) needs. TESSe2b system is the outcome of a Horizon 2020 funded project intending to deal with the above issue, through the enhancement of energy efficiency in buildings. Its aim is to enable the optimal use of renewable energy sources (RES) and to provide a solution for correcting the mismatch that often occurs between the supply and demand of energy in residential buildings. The target of TESSe2b is to design, develop, validate and demonstrate a modular and low cost thermal storage technology based on solar collectors and highly efficient heat pumps for heating, cooling and DHW production. The idea is to develop advanced compact integrated PCM (Phase Changing Material) TES (Thermal Energy Storage) tanks exploiting RES (solar and geothermal in particular) in an efficient manner, coupled with enhanced PCM BHEs (Borehole Heat Exchangers) that will utilize the increased underground thermal storage and maximize the efficiency of the GSHP (Ground Source Heat Pump).

A key-issue regarding the success of the technology's diffusion is consumers' behaviour. The present study aims to examine the factors that affect thermal energy systems' adoption through consumers' self-reported behaviour, based on the socio-cognitive theory.

2. MATERIALS AND METHODS

A behavioural survey was performed in three EU Member States (Greece, Spain and Portugal) between June 2016 and February 2017. The collection of the developed questionnaire was performed through the project's and partners' websites and social media. It should be mentioned that although the collected sample is not totally representative of the population, since internet surveys do not create samples as representative as telephone or face-to-face surveys [1], it can provide a good basis [2] for the examination of the factors that affect the issues under examination.

In total, 400 fully completed responses were collected: 159 from Greece, 109 from Portugal and 132 from Spain. Separate statistical analysis (SPPS 24) was performed for each country, including simple descriptive statistics for the initial analysis, and procedures such as chi-square tests, non-parametric Mann-Whitney tests and binary and ordinal logistic regressions (in total 24 regression models: eight different investigated issues for each one of the three countries) in order to examine the effect of socioeconomic and residence characteristics on issues such as a) measurement of thermal energy use, b) previous investments in thermal energy systems (conventional or RES) and storage and c) adoption perceptions and intentions for the TESSe2b solution. In addition, chi-square tests and Kruskal-Wallis tests were applied to evaluate the existence of any differences between the three countries' responses.

3. RESULTS

In Greece and Spain, about 35% of the respondents measure and record their use of thermal energy; the equivalent percentage in Portugal is lower than 20%, presenting, in fact, a statistically significant difference with the other two countries. The respondents of the three countries present similar results concerning investments in thermal energy systems in the past five years (40-50%), investments in thermal energy systems using RES in the past five years (22-33%, with the positive responses from Portugal being lower on a statistical significant level) and investments in thermal energy storage in the past year (10-14%). In all countries, the majority of the respondents agree that the TESSe2b system can offer benefits, while there is a positive attitude concerning adoption intention of the system. Respondents state that they would be willing to pay (WTP) up to € 6,000 for the installation (with Portuguese WTP being lower on a statistically significant level, compared to the Spanish respondents), while an acceptable payback period of the installation cost would be up to five years.

The statistical analysis also reveals the different socioeconomic and residence characteristics affecting in a statistically significant level the examined themes. Although the results slightly differ for each issue under investigation among the three countries, a general approach is that respondents a) with: a higher than average income, a high level of education, an occupation relevant to energy/ environment and b) living in a residence that: is self-owned, outside urban areas, newly constructed, not in an apartment building and has an higher than average size are more likely to measure and record their thermal energy use and to have invested in thermal energy systems (either conventional or using RES) and storage.

The factors that have been found to affect the issues concerning the installation of TESSe2b system are in general common with the abovementioned characteristics, with one difference and two additions. Specifically, respondents living in older residences, using conventional sources for heating and DHW (heating oil, natural gas, electricity) and spending a higher than average percentage of their income for household energy needs are more likely to have a more positive benefit perspective and adoption intention and to present a higher level of WTP and acceptable payback period for the TESSe2b system.

4. CONCLUSIONS

The present study examines the socioeconomic and residence characteristics that affect thermal energy use measurement, investments in thermal energy systems and storage and installation of the TESSe2b system (perceived benefits, adoption intention, WTP, acceptable payback period). The findings of the study contribute to the understanding of the behavioural patterns of consumers regarding the selection and installation of residential thermal energy systems.

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CUMULATIVE ENERGY DEMAND OF ADOLESCENTS' DIGITAL MEDIA BEHAVIOUR

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Keywords: LCA, digital devices, adolescents, environmental impact, CED, digital media, cell phone

1. INTRODUCTION

The use of digital media has become an integral part of our everyday life. At first glance, energy is only required for charging devices. However, energy input is also needed for manufacturing devices and for data transfer. In the interdisciplinary project "Digital Sufficiency", the cumulative energy demand (CED) of digital media use by Swiss adolescents was modelled with a life cycle assessment. The project was funded by the Mercator Foundation Switzerland.

2. MODELLING APPROACH

Modelling was based on digital media behaviour data. A survey was carried out to gather detailed answers from more than 800 Swiss adolescents aged between 12 and 25. These data were adapted to represent the average Swiss young person [1], [2]. The results were supplemented with data on device ownership from the JAMES-study [3]. Since most adolescents have multiple devices, the survey focused on the use of devices that have multiple uses and are widespread: mobile phones, tablets, laptops, desktops and televisions.

For each type of digital media use (i.e. sending text messages), the following aspects were included: the electricity demand for charging the devices, the electricity and equipment needed for data provision (data centre) and transfer (WLAN, mobile antenna, international network). In addition, the pro-rata energy requirement for manufacturing the devices was included. To calculate the energy demand associated with data transfer, an average data volume per behaviour was compiled. Modelling of the internet and the devices was based on the Green Media Calculator [4], [5], [6]. The CED was calculated with the method proposed by Frischknecht et al. [7]. As background data, the Swiss database ecoinvent, version 3.2 [9] was used (system model: "Recycled Content" corresp. "cut-off").

3. RESULTS

The average 12 to 25 year old Swiss individual's digital media use has a cumulative energy demand of roughly 11 megajoules per day. Of this energy, almost 90% is non-renewable. The analysis showed that the production and disposal of the devices accounts for more than half of the energy (see Figure 1). Devices owned by the adolescents themselves as well as those that are shared within the family (pro-rata) were accounted for. More than 40% of the CED results from televisions, since almost every family (96%) and nearly one in three adolescents owns a television. Another reason is that televisions need more energy than smaller devices both for the production (higher material demand) and use phase (direct energy use; larger data transfer due to high image resolution.)

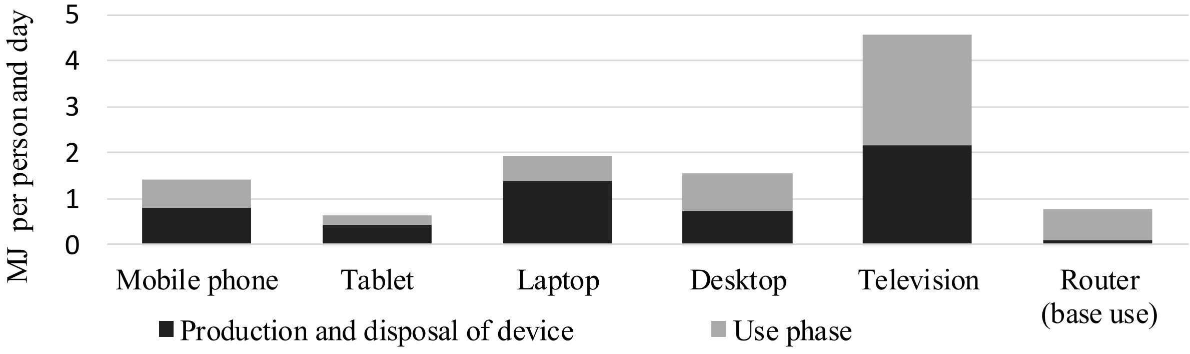

Figure 1: Cumulative Energy Demand of digital media use of adolescents per person and day.

The devices direct electricity consumption contributes approx. 16% to the total CED: desktops and televisions each contribute 6%, laptops 3% and the remaining devices less than 1%. The transfer of data from the device to the data centre and within the internet is of little relevance. The base use of the router (stand-by) accounts for 6% of the energy demand. Processing and provision of data in data centres is negligible for all activities, except for televisions (16%) and video viewing (3%).

5. CONCLUSIONS

When assessing the cumulative energy demand of digital media use, it is important not only to consider the direct energy use of devices, but also include the indirect energy needed for production of the devices. Data provision in data centres is only relevant for data intense uses.

To reduce the energy demand, the following recommendations can be given: (1) Sharing devices and avoiding buying new ones by increasing their lifetime. (2) Switching from energy intensive devices like desktops and televisions to more efficient devices like mobile phones. (3) Reducing the number of new devices purchased has the biggest reduction potential.

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CAPTURING THE ENERGY EFFICIENCY BENEFITS OF SMART METERS IN THE NON-DOMESTIC SECTOR: USING NOVEL RESEARCH METHODS TO INFORM INNOVATION IN ENERGY MANAGEMENT SOLUTIONS.

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Keywords: Smart meters, energy management, innovation, behaviour, action research.

1. INTRODUCTION

The British Government is leading a major energy infrastructure project, with all homes and smaller non-domestic sites being offered a smart meter by the end of 2020[1]. Smart meters have the potential to transform energy management by providing non-domestic consumers with real time, relevant and reusable information to help them better-manage their consumption [2].

Existing research has shown that engagement with smart meter data varies considerably across non-domestic sites, depending on their size, energy intensity, organisation structures and resources [3]. SMEs face additional barriers to behaviour change, ranging from lack of awareness/understanding of smart meters and potential savings, to skills and capacity issues [3]. However, research also suggests that having access to smart meter data has the potential to prompt many SMEs into taking action to reduce their energy consumption, provided they know how to interpret information and cost effective solutions are easy to access [3]. Evidence highlights the value of developing appropriate products and services which help organisations understand their energy use and identify practical ways to save energy [3]. This paper summarises research undertaken by BEIS and UCL which has informed a new, innovative approach to helping improve energy management among SMEs in Great Britain.

2. APPROACH

It is well known that the non-domestic sector is highly heterogenous in terms of both organisational activities and associated energy use [4]. Evidence has shown that some sub-sectors (segments) are considerably more energy intensive than others (e.g. hospitality, retail and some public sector organisations) [4]. Due to differing organisational activities, possible energy efficiency solutions differ considerably in their potential and desirability, one size does not fit all [5]. Furthermore, organisational contexts, capacity and concerns all play key roles in take up of energy efficiency measures [6].

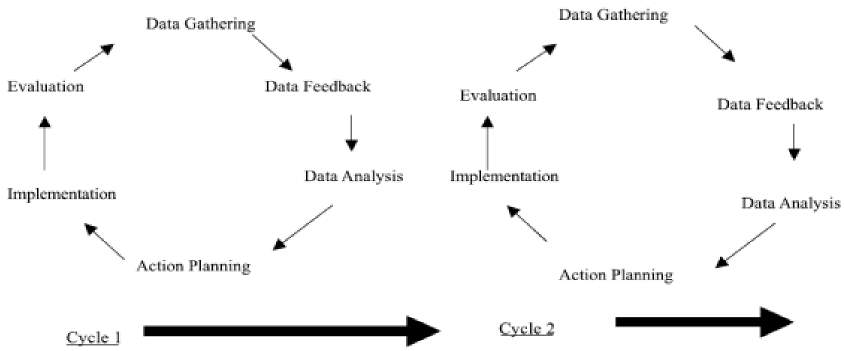
Recent further research by BEIS and UCL focused on energy management interventions and smart meters has shown that for smaller organisations [3, 7], solutions need to be:

- Relevant to specific segments and their organisational activities
- Simple, timely, tailored and easy to access
- Informed by behaviour change expertise to help translate awareness into action.

In response to this evidence, BEIS has developed a new, innovative policy approach to tackle these issues, in the form of a Non-domestic Smart Energy Management Innovation Competition (NDSEMIC) and associated NDSEMIC Research and Evaluation Programme (REP), to be delivered between 2018 and 2020 [8]. NDSEMIC comprises up to £7.3M funding for smart energy management innovators to develop products and services based on data analytics using smart meter data, for smaller non-domestic sites across five energy-intensive segments (independent & chain hospitality and retail, schools). Its aim is to develop the market for, and maximise the overall uptake and impact of, such products and services, in order to help secure energy demand reduction within target segments of the non-domestic sector [8].

Aligned with the competition is a large-scale research & evaluation programme (REP). Alongside traditional evaluation activities, the REP adopts a novel 'action research' approach. Action research is a research methodology which brings together researchers and their subjects – using a test, learn, adapt cycle to inform solutions (Figure 1). It has not been used extensively in this sector, but learning from other sectors has shown it is a potentially powerful approach for developing solutions which work for their target audiences [9].

Figure 1: Action research cycle [9]



This novel research approach is designed to directly support competition innovators by using action research to help inform new effective solutions for these sub-sectors, iteratively feeding findings in to adapt products, services and market engagement strategies as necessary to reflect latest evidence.

3. CONCLUSIONS

Recent research indicating that innovation can be a vehicle through which barriers to energy management in SMEs can be addressed has prompted BEIS to develop both a novel approach to energy management solutions and an accompanying novel methodological approach to build the evidence base.

The NDSEMIC Competition and REP will promote innovation in specific energy intensive non-domestic segments, and use action research to:

- Inform Competition participants solutions to maximise potential market take up and efficacy in improving energy management
- Add to the evidence base about 'what works' to facilitate behaviour change, in what contexts and why.

The research methods used have been applied successfully in other sectors including health and education, but not in the energy sector. Given inherent challenges within non-domestic energy policy, this work is viewed as an important innovation which could inform new ways to significantly improve policy-making in this sector.

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ACTOR-RELATED FACTORS OF INFLUENCE ON PLANNING AND IMPLEMENTATION OF ENERGY EFFICIENT COLD SUPPLY SYSTEMS

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Keywords: Absorption chiller innovations, Energy efficiency, Demonstration projects, Planning and implementation process, Multi-level perspective, Interviews

1. BACKGROUND AND OBJECTIVE

The refrigeration sector is predicted to rise substantially worldwide in the upcoming years, even in Western Europe. Broad dissemination of more energy efficient cold technologies and systems is one of several urgently required measures to counter a correspondingly rising energy demand. Up to now, research has been focused on technological and economic aspects. More comprehensive analyses including societal and actor-related factors affecting successful implementation and diffusion of these technologies are rare. My socio-technical research in a project on innovative absorption chillers targets this gap [1].

The objective of my talk is to contribute to a more differentiated understanding of the interplay of social and technical factors during the course of commercial technology planning and implementation processes of energy efficient technology systems.

2. METHOD AND PROCEDURE

The presented material is based on interviews with actors involved in planning and implementation process in technological demonstration projects. In these so-called field tests installations of central cold systems in office buildings, consumer market, and others, innovative, more energy efficient, absorption chillers are tested and optimized. Interview partners were facility managers, planners, energy suppliers, and researchers. The interviews focused on their experiences during planning and installation process.

3. THEORETICAL APPROACH

Analysis was based on the multi-level-perspective, an approach from science and technology studies [2]. Here, demonstration projects (field tests) are conceptualised as "local experiments" which (hopefully) contribute to learning processes, alignment of expectations, and social network development, which are essential for further diffusion of radical technical innovations in socio-technical regimes [3].

4. INTERVIEW RESULTS

Absorption chiller systems are very complex, heterogeneous systems. They have to be integrated into building energy systems which are complex as well. Due to the low level of standardisation (no plug-in systems), individual, case-related planning and adaptation is necessary for every single system. Concerning actor structures, there is a high degree of division of tasks and responsibilities (overall planning, electrical and hydraulic implementation planning, facility management, company management, building owner). Thus, technological optimisation depends very much on factors affecting quality of communication and collaboration (development of a common language and understanding, clear responsibilities, good information flow, communicative skills, ability and readiness of actors to deal with necessity of adaptation of partial planning to overall plans, and others). The innovative character of the deployed plant technology, the target of maximising overall systems' energy efficiency, and research – practice collaboration increase (already high) requirements on planning and implementation. Misunderstandings (partly unperceived until technical problems occurred during implementation) and conflicts resulted, among others, from

- (unnoticed) different paradigms of striven cold system and planning objectives;
- insufficient understanding of operating principle of the innovative plant, and related extended design options;
- data requirements deviating from what is usually required;
- demand for additional knowledge and know-how, even for persons experienced with absorption chiller technology;
- timing of information transfer, and
- planning procedure with iterative, collaborative specification of technical requirements.

Additionally, activities, requirements and decisions outside the planning team affected financial, spatial, and technical possibilities and limits of energy efficient planning and implementation, e.g. from decision-makers in companies, architects, general contractors, or colleagues who want to work according to established routines.

5. CONCLUSIONS

Planning and implementation of energy efficient absorption chiller systems require skilled and experienced actors which are able and willing to integrative thinking and planning, to think "outside the box" of their own area of responsibilities. Besides enhanced professional expertise, social skills (in communication, collaboration), willingness and ability to change established routines and paradigms in planning and implementation are essential. Not least, decisions and activities from external actors can create free spaces for or limit energy efficiency. Consequently, future promotion of energy efficient cold supply systems should pay closer attention to impacts of actor-related factors and their interplay with the larger societal context related to decisions and activities of building energy planning.

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ANALYSIS OF USER BEHAVIOR REGARDING COMMERCIAL DISHWASHERS IN GERMANY

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Keywords: commercial dishwasher, behavior, survey, Germany

1. INTRODUCTION

The consumption of food outside people's homes is increasing these days due to a decreasing time budget. A risk of infectious diseases caused by food-related microorganisms exists in these commercial institutions [1]. Special attention must be paid to good hygiene practice to prevent consumers from potential pathogenic microorganisms especially in facilities such as hospitals, playschools or rest homes, where the so-called YOPIs (young, old, pregnant and immunosuppressed people) are fed. Food and food residue provide germs with an optimal breeding ground [1].
All objects which come in contact with food must be cleaned hygienically and the residue disposed of to prevent the health risk [2]. These objects, so-called washware, includes all dishes, cutlery and cookware. The cleaning procedure in commercial institutions is carried out mostly by a commercial dishwasher. The cleaning result required and the environmental impact it has depends on the technique of the commercial dishwasher and its proper use [2]. Unfortunately, there is almost no (scientific) knowledge available about the actual use and the associated effects on hygiene and use of resources by commercial dishwashing. It was, therefore, the task of this research to investigate the user behavior regarding commercial dishwashing habits in Germany and to assess its environmental effects.

2. METHOD

The survey was conducted in North Rhine Westphalia in commercial/industrial institutions with commercial dishwashers. All kinds of commercial dishwashers were represented in the participating institutions. A total of 151 participants were recruited. An initial survey was developed with more than 20 qualitative questions in the form of a semi-structured questionnaire. The participating institutions were asked about dishwashing behavior, the amount of washware, residues, cleaning problems, detergents and cleaning times in face-to-face interviews. Furthermore, correlations between cleaning problems and different cleaning parameters were analyzed. Afterwards, possible mistakes and impact factors relevant for the environmental effects or which lead to an undesirable result were determined.

3. RESULTS AND DISCUSSION

Institutions of public catering, and the hotel and catering sector participated in the survey. Almost 30 % of them represented different kinds of restaurants. Only 5 % were hospitals. Most of the institutions used single-tank undercounter dishwashers, whereas basket transport dishwashers are the kind least used. An average of 126 cleaning cycles per day were conducted. Restaurants reached up to 600 cycles per day in contrast to hospitals where only 5 cleaning cycles per day were performed. The median of the daily amount of washware is between 380 and 955 items, depending on the kind of institution. Almost half of the total washware has to be cleaned during the rush hour. Many participants declared that the all the washware is pre-rinsed before mechanical cleaning because of the poor cleaning results offered by the dishwasher. The cleaning temperature of the commercial dishwashers is between 55 and 70 °C. The amount of food residue resulted in amounts from 60 g (single-tank undercounter) up to 220 g (undercounter with a water-change system) per cleaning cycle.

Regarding the amount of washware per cycle, most of the capacity available of commercial dishwashers is not used, especially outside the institutional rush hour. The highest discrepancy between the capacity available and real-life loading was revealed in institutions with a conveyor belt dishwasher. In this case, more than two-thirds of the available capacity is not used. Otherwise capacity problems can occur during the rush hour.

The results of the survey show that the cleaning result is negatively influenced by a higher amount of food residue. The higher the amount of residue per piece of washware, the more cleaning problems occur. A correlation between the loading of the dishwasher and the cleaning result can also be determined. If the washware is sorted well in the baskets, the cleaning result is more often satisfying. Against expectations, no correlation is detected between the cleaning temperature and duration of drying of food residues on dishes.

The undercounter dishwashers with a water-change system especially showed capacity problems during the rush hour. More than half of the participants run a cleaning cycle with about 200 pieces of washware.

4. CONCLUSION

The results of the survey emphasized the importance of a better education of the users of commercial dishwashers. A perfect cleaning result depends on the right use and frequent servicing conducted by the manufacturers or their agents. A clear communication between manufacturers, consumers and legislative bodies is necessary to achieve satisfactory results with the least possible implications on the environmental effects.

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COEVOLUTION OF HOUSEHOLD PRACTICES AND SPATIAL LAYOUTS: A CASE OF RISING MIDDLE-CLASS ELECTRICITY CONSUMPTION IN THE GLOBAL SOUTH

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Keywords: Practice theory, Electricity consumption, Household practices, spatial layout, Global South.

Introduction: This paper seeks to address the gap in energy-use studies in the Global South from a socio-technical perspective. It presents a practice-based analytical trajectory of increasing electricity consumption in middle-class households in Lahore, Pakistan, as a case-study. Analysis of the changing house spatial layout and accompanying household practices over the last century in Lahore was carried out. This helped identify various nexuses of 'practice-arrangement bundles' [1] of urban housing that have emerged, persisted and transformed over time giving rise to unsustainable levels of household electricity consumption. Similar trends of rapid urbanisation and escalating population of high-consuming middle-class in the 'rising' South [2] imply broader methodological applicability of the current research. Most energy efficiency policies targeting domestic consumption are typically based on divided behavioural or technological solutions, while failing to grasp deeply embedded socio-cultural practices and material arrangements that determine processes of change [3],[4],[5]. A study of the interconnection between household practices and spatial layouts and their coevolution over time can help conceptualise domestic energy demand and provide better understanding of how and why more resource-intensive configurations have taken root with possible policy implications for sustainability.

Methodology: The methodology is based on Schatzki's [1] practice theoretical framework of social order as a plenum of practice-arrangement bundles, to unravel connections between household practices and house spatial layout. Mixed-method approach was adopted for collecting data. In-depth analysis of case-study houses from different historic periods in Lahore, six oral history interviews with older residents and a panel discussion with seven middle-aged housewives were conducted to get rich personalised information on co-evolution of social practices and house spatial functions. In addition, detailed review of archival documents, including house plans as well as planning and building regulations was carried out for the last century to understand changes in house spatial configurations.

Findings: Analysis reveals three key process of change in household practices and spatial layouts, which have resulted in increasing household electricity demands over the last century in Lahore;

1. Multifunctional spaces to fixed, individualised use; traditional multi-purpose spaces with non-specified rooms, inclusive zoning of neighbourhoods, temporally differentiated practices and segregated gender-use gradually diminished over time. This was replaced by functional specificity of spaces, such as through introduction of dining rooms, initiated by colonial aspirations and concern for public health and hygiene, for example through specifications for proper air-circulation. This, together with individualised use of spaces furthered by Westernised notions of modernism, for example in separate study and recreational spaces, resulted in increase

in overall space-usage and ultimately increased electricity-use.
2. Inwards to outwards design; introverted traditional houses based on layers of private/public divisions transformed into the colonial bungalow-style house with its outward configuration of grid-planning and peripheral open spaces, which became standardised in post-colonial housing. The introverted design allowed smooth flow of indoor-outdoor activities, while upholding cultural notions of privacy and segregation. This was most evident in use of inner courtyards as the centre of household activity in vernacular houses. On the contrary, outwardly designed, closely-spaced modern houses under post-independence building regulations resulted in creating outdoor peripheral 'negative spaces' that stand in contradiction to socio-cultural meanings still prevalent in society, giving rise to conflicts between practices and their spatial settings.
3. Outdoor to indoor activities; growing material dependence, increased accustomation to mechanical means of comfort with higher standards of living and increased reliance on electricity-use for performance of routine practices served to diminish outdoor activities while reinforcing use of indoor spaces. This is also evident in increasing trends of electrical appliance ownership. Sedentary indoor lifestyles are further supported by gradual changes in building regulations limiting mandatory open spaces while increasing permissible covered area on site.

Conclusions: Findings of the paper show that increasing household electricity demands can be better explored through analysis of historic coevolution of household practices and spatial layouts. Key themes identified reveal that electricity demand is embedded in emerging, persisting and evolving household practice-arrangements bundles. In case of Lahore, these bundles are bound by factors like colonisation and westernisation, building regulations, changing notions of home and comfort, technological advancements in electricity-use as well as changing fabric of community life. The study shows that understanding longitudinal changing dynamics of practice-arrangement bundles can help recognise and prevent normalisation of increasing standards for the 'perfect' home, that become embedded and engrained in social practices and institutional systems. The study suggests that improvements in future energy demand policies necessitate consideration for sustainability *both* in infrastructural material arrangements and in household practices. For Lahore, more sustainable material arrangements, such as introverted house layouts with multifunctional spaces, elimination of non-functional negative spaces and smooth merger of indoor-outdoors need to be incorporated with more sustainable practices such as outdoor entertainment activities and reliance on passive comfort (to mention a few). Such a 'bundling' of more sustainable practice-arrangements can help transition towards more sustainable demands for electricity. For this, housing development and building regulations need to work in tandem with behavioural approaches for efficiency, so as not to contradict each other and also offer solutions that are consistent with the climatic and socio-cultural context. Though applied for a single case-study area, the methodological framework presented can prove evincive to wider questions of rising energy consumption in the Global South.

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PUBLIC ENERGY ADVISING IN THE INTERNET AGE – CHALLENGES AND OPPORTUNITIES ON THE ROAD TO MORE ENERGY EFFICIENCY

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Keywords: Energy advising, Households, Energy efficiency, Behaviour, Sustainable development

1. INTRODUCTION

Energy advising services are one of several government instruments for improving the efficiency of energy usage in many European countries. The implementation in Sweden was, and still is, based on a decentralized organization with energy advisors located in the municipalities. The development of the service to date is described in [1]. Long-term holistic thinking supported by different policy instruments, such as regulations, energy advising and subsidies, is needed. Recently, the development of decentralized energy systems has necessitated targeting individuals with information.

In Sweden, there has been a drop in the number of households using this service, even though it is offered independently, free of charge, and is easily accessible. Instead, Swedes have increasingly been seeking information on the Internet, which can be seen as both a challenge and an opportunity for the energy consulting service offered [2]. Many minor questions can be answered via a good web site. The Internet also offers the chance to exchange information and experiences with others and solve minor technical problems in special forums, especially if informative pictures or films are provided. Change of heating system or renovation/reconstruction are, however, situations in which the personal meeting can be far superior to the Internet in terms of information and also to be preferred for a house owner. Conclusions in Darby [3], include the finding that low-income households are in the greatest need of help, not least regarding simple tips on how to reduce energy usage. Aune [4] has observed that there is no clear economic rationale behind how people decide to do different things in their households.

When a house is sold and the new owners want to renovate/rebuild the property, this is a point at which people generally are more easily persuaded to take energy saving measures, which the governments in Denmark and Norway have taken advantage of for several years, giving grants to consult an advisor to inspect a new home. Household members can discuss their ideas and requests directly with an experienced consultant in their home. Tjörring [5] is clear in her recommendations to energy advisors: “We must focus on the home not only as a technical issue that can be improved but also as a dwelling space that contains gendered practices, cultural norms and social engagements among the home, the family and the energy advisor.”

The question is: What role can personal energy advice have in an increasingly digitized society?

2. RESULTS

Several interesting reflections can be made on the basis of the literature review [2] presented here in relation to the three pillars of sustainable development. This is illustrated in Figure 1.

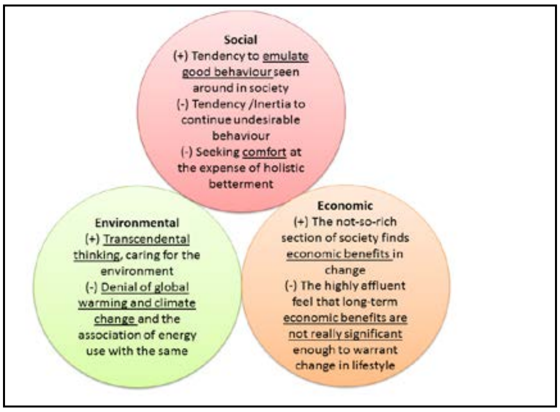

Figure 1. Human behaviour in the context of household energy usage in relations to the three aspects of sustainable development.

Traditionally, energy advising has been strongly associated with and driven by economic considerations. If a technical or behavioural measure is to be undertaken in a household today, this is only part of the basis for decision [4]. Social aspects like trends, life styles, influence of friends and neighbours are strong factors as well as environmental aspects. The study is based on a literature review and on reviews of documents like governmental bills, reports and evaluations. One survey and semi-structured interviews with interview guides has also been done.

3. CONCLUSIONS

Below are the main conclusions drawn from the studies that will be presented at the conference:

- Consumers expect more tailor-made information related to their specific needs, than before. Here, the three dimensions of sustainable development can be useful.
- Equality theme: Do not neglect women
- In the 1980s, it was common practice for the advisor to request property data before the consultation. Today, it is more important to know the personalities/lifestyles of the household.
- The personal meeting has advantages as well as disadvantages.
- More research is needed regarding how and when households seek information as well as on how best to communicate information. This requires interdisciplinary collaboration.

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A SOCIAL VALUES-BASED PERSPECTIVE ON PEER-TO-PEER ENERGY SHARING SYSTEMS

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Keywords: Peer-to-peer energy trading, Energy sharing, Social value, Values-based indicators, Assessment framework, Synergies

ABSTRACT

Peer-to-peer (P2P) energy sharing represents flexible electricity exchange among grid-connected peers [1]. From this perspective, prosumers (i.e., those who both produce and consume electricity) who have surplus electricity generation can share or trade it with other grid-connected peers who are in electricity deficit, as an alternative to injecting it into the main grid [1],[2]. This innovative market model is influenced by the sharing economy concept, being supported by multiple and flexible networks of individuals that generate, manage and trade electricity in a collaborative manner [3]. The first attempts to implement P2P energy sharing models in real market conditions started to appear recently around the world. It was first promoted in the Netherlands and then Germany, the UK, the USA, Australia, and is growing [4]-[9]. To date, these existing initiatives have not been translated into a wide array of tangible examples and still need to be upscaled from their local or regional markets. From a whole systems thinking perspective [10], research indicates that P2P energy sharing could have a positive impact on societal systems through synergistic human-to-human interactions. Yet, apart from a few examples [11],[12], the majority of research on P2P energy sharing fails to investigate its potential social values-based dimension. Instead, they focus on the development of the technological attributes and business specificities associated with them [13]-[20]. This study argues that these reductionist techno-economic approaches towards P2P energy sharing only address part of its potential. Therefore, this research proposes to scrutinise the assumption that social values emerge as a core outcome of P2P energy sharing interactions. To do this, the study introduces a pragmatic values-based assessment framework for the evaluation of social values deriving from P2P energy sharing initiatives. This methodology will be trailed in 3 community-based P2P energy sharing pilots in Portugal under real market conditions by the end of 2018. These pilots are also briefly reviewed in terms of their techno-economic feasibility, which are currently limited by regulatory barriers in the country. With that said, by investigating P2P energy sharing initiatives through a whole systems thinking perspective, this study aims to uncover the capacity for P2P processes to act as a lever for qualitative growth of social benefits. By doing so, this paper aims to provide an effective way to factor in social values when implementing P2P energy sharing models from a constructive social values-

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IN HOW IS SOCIAL SCIENCE REFLECTED IN EUROPEAN POLICIES? AN ANALYSIS OF POLICY DOCUMENTS[i]

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Keywords: Policy analysis, social science, energy policy, electric mobility, photovoltaics, energy in buildings, smart meters, energy providers.

1. THE NEED FOR SOCIAL SCIENCE IN THE ENERGY TRANSITION

Social Science and Humanities (SSH) input to energy transition research has been requested for a number of years on the national and international level. Central policy documents on the European Union level like the Strategic Energy Technology (SET) plan[ii] or the Clean Energy for all Europeans Package[iii] (also referred to as the Winter Package) have identified consumers as key actors in realizing the Energy Union and providing clean, affordable and reliable energy. Activating consumers and citizens requires a substantial understanding of their life situations, contexts and lifestyles, their attitudes, values and decisions. This has resulted in increased research activity in the SSH sector, both as an integral part of technology developing projects and as part of interdisciplinary projects exploring the different SSH disciplines and the benefit of a comprehensive perspective on central themes of the energy transitions initiated in the European Union.

Reading the key policy strategy documents on the EU, Member State, but also more local levels makes it obvious, that the urge to understanding and integrating citizens in energy transition activities is strong. However, it also appears that the depth of understanding of the complexity of human behaviour and its embeddedness in culture, structures, governmental frameworks and belief systems is only superficially reflected. As a consequence, the potential of SSH knowledge seems to be utilized only to a small degree in policymaking.

2. A SYSTEMATIC STUDY OF POLICY AND STRATEGY DOCUMENTS

The ECHOES consortium *systematically* analysed how consumers are integrated into policy documents on different levels, which assumptions about the factors influencing their decision making are directly or indirectly reflected in the documents and which policy measures are directly referring to SSH knowledge. This presentation displays the results of a thorough analysis of more than 100 select-

[i] This presentation is an introduction to the special session "SOCIAL SCIENCE INPUT TO ENERGY TRANSITIONS: MAKING SOCIAL SCIENCE POLICY RELEVANT – INSIGHTS FROM THE ECHOES PROJECT"

[ii] https://publications.europa.eu/en/publication-detail/-/publication/771918e8-d3ee-11e7-a5b9-01aa75ed71a1/language-en/format-PDF/source-51344538

[iii] https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans

ed key policy documents on the level of the EU, Member States and regions. In addition, a brief analysis of an electricity company's strategy documents is included to contrast policy documents with business strategies and learn, if there are differences between these sectors.

3. RESULTS

First, the consumer has made his/her way into policy documents on all levels. It is now a shared understanding that Energy Transitions and the Energy Union require a substantial engagement of consumers in addition to technical or governance developments. However, the analyses also indicate that this increased interest is not adequately nor fully reflected given the rich understanding of the complexity of human decision making as well as policy instruments addressing this complexity. The main overarching assumption reflected in most analysed policy documents is that (a) consumers are important actors, (b) they lack information and given they are provided with the right information they will act accordingly, and (c) consumer behaviour is based on economic considerations, which calls for monetary incentives, subsidies and price regulations.

The analyses show clearly that social science knowledge has a strong potential to enhance policymaking to a far larger extent than is implemented in most of the documents analysed. Whereas we do not question the necessity of providing consumers with information about their energy use, alternative technologies, energy production, and smart appliances, we strongly doubt that this alone will stimulate strong changes in consumer behaviour. The picture is a bit more diverse for the strong rational choice assumptions underlying many policy packages. In some domains, such as the diffusion of decentralized photovoltaics, the success of economic policy measures and net regulations has proven to be a decisive factor. However, this is overshadowed by the dimension of psychological control about the stability and trustworthiness of the schemes. In other domains the over-rationalistic approach has clearly failed. The purchase of a car is far more than a basic rational choice and can be influenced by cultural meaning of car ownership, status considerations, norms, values, group processes, trust in producers and technologies, visibility of new technologies and thus communication of normality (descriptive norms), etc. With a different angle, this is also true for smart metering. Here trust in the motives of the data handler and technological security are decisive factors, which can only partly be addressed through information campaigns alone.

The presentation will also show recommendations from the ECHOES perspective to increase the effect of policy by employing a more diverse social science approach in policies and strategy documents.

SOCIAL, STRUCTURAL, PERSONAL AND CONTEXTUAL FACTORS OF PROSUMING IN HOUSEHOLDS

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Keywords: Photovoltaic Systems, Prosuming, Motives, Factors, Attitudes, Households

1. INTRODUCTION

Turning away from fossil energy and advancing the structural change towards a more decentralised energy supply entail tremendous societal challenges. The role of private households not only as consumers but also as producers of electricity (i.e. *prosumers*) becomes increasingly important in this system change. A common way of private energy production are photovoltaic systems. In Germany, triggered by feed-in tariffs, the entire energy generated by households has traditionally been fed into the central energy grid. However, legislation has recently changed, and it is now more attractive to consume the self-generated electricity at the own property. This development contributes to grid stability. Against this backdrop, the present study is aimed at gaining a deeper insight into what motivates households to adopt photovoltaic systems and, thereby, become prosumers. Possible social, structural, personal, and situational influencing factors were explored in qualitative interviews (semi-structured, N = 22). Target groups were *adopters*, that is, homeowners who had already installed a photovoltaic system and *non-adopters*, that is, homeowners who had actively decided not to install a photovoltaic system.

2. METHOD

The interviews were conducted according to a guideline, which included questions about the social and situational context of prosuming, the reasons for the decision for or against prosuming, and structural and personal influences on this decision (for example, how the decision was affected by becoming autarchic or by legal requirements). Additionally, demographic information about the participants and technical data concerning the photovoltaic systems (of adopters) were collected. As for adopters, households that directly used the energy produced by their photovoltaic systems were preferred during the recruitment. Participants were recruited in the German Federal States of Hesse and Baden-Wuerttemberg via selective inspection of both urban and rural residential areas as well as expert contacts and specific internet platforms. The sample consisted of 13 adopters and nine non-adopters. Among the adopters, eight households directly used the energy produced by their photovoltaic systems and five households fed the entire energy into the central grid.

Among the non-adopters, six households used an alternative system to produce energy, mostly solar heat, and three households did not use any alternatives to photovoltaic systems.

The interviews were transcribed and analysed with qualitative content analysis according to Mayring [1]. Coding categories were mostly derived from the Photovoltaic Systems Acceptance Model [2] and included amongst others *Financial, Economic, Environmental* and *Social Benefit, Specific Costs Installation*, *Operation, Expense* and *Information* as well as *Perceived Autarchy* and *Benefit of Subventions*. These benefits and costs were explored with regard to (a) how *important* they were perceived for adopting a photovoltaic system and (b) what degree they were deemed *characteristic* of existing photovoltaic systems and prosuming.

3. RESULTS

The characterising profiles of the two groups - adopters and non-adopters - differed markedly. Adopter interviews revealed that a high *Financial Benefit* was both considered important for the decision to adopt a photovoltaic system as well as characteristic of such systems and prosuming. Furthermore, high *Specific Costs Operation* of photovoltaic systems and prosuming were regarded to be uncharacteristic. Non-adopters found high *Specific Costs Expense* of photovoltaic systems and prosuming to be important and highly characteristic. *Environmental Benefit* was considered important by both groups. In sum, these findings illustrate that the beneficial effects on the natural environment caused by prosuming play an important role for both adopters and non-adopters. However, while adopters seem to focus on financial benefits, by saving money for electricity, non-adopters seem to rather focus on strains and risks, among which high initial expenses are dominating.

Further analyses within the adopter group indicated a discrepancy regarding *Perceived Autarchy*. While autarchy was perceived important for adopting a photovoltaic system, it was considered only little to moderately characteristic of such systems and prosuming. Thus, people seem to strive for a high degree of autarchy through their photovoltaic systems but feel like they cannot achieve it. With regard to *Specific Costs Expense*, analyses within and between the groups showed that non-adopters as well as adopters found it important to have low initial expenses, whereas the actual or expected expenses were high. Another striking discrepancy was found for *Specific Costs Information*. Non-adopters felt that accessing relevant information was costly and time-consuming, quite in contrast to adopters, who described the access to information as easy and uncomplicated.

4. DISCUSSION

From a technological point of view, a higher degree of autarchy through photovoltaic systems is likely to be a driver of adoption. Furthermore, lower information costs could support adoption. One approach to lower information costs may be to establish single points of professional and industry-independent consultation. Overall, investment costs are perceived to be high; thus, lowering investment costs or providing risk-benefit analyses to interested parties could decrease the perceived insecurity of the investment. As perceived environmental benefit is generally considered important, personalised feedback on household achievements in this domain through photovoltaic systems could encourage prosuming.

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ANALYSIS OF CURRENT TRENDS IN THE RENTAL ACCOMMODATION MARKET FOR STUDENTS AND THEIR IMPLICATIONS FOR FUEL POVERTY

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Keywords: energy poverty, fuel poverty, university students, market analysis, residential buildings

1. INTRODUCTION

Fuel poverty is a socio-economic problem with severe health impacts potentially occurring when individuals are unable to afford adequate energy services in their home on their present income [1]. It affects millions of households across Europe [2] and is generally triggered by a combination of low incomes, high fuel costs and the poor energy performance of the housing stock [3]. Bouzarovski et al. (2012) [4] suggest that young adults are often an under-reported and under-supported group of the population that suffer from fuel poverty – they state that "in addition to the poor knowledge of thermal comfort and energy efficiency standards", the situation of young adults is "in part attributable to the widespread cultural expectation that is acceptable for individuals in this demographic group to live in poorly heated and low quality housing". The present study aims to expand on the findings of the UK-based 'Homes Fit for Study' [5] research in order to understand the experience of students living in the private rented sector in six additional EU countries (namely Bulgaria, Cyprus, Greece, Ireland, Lithuania and Romania) and to formulate recommendations of tackling fuel poverty within those countries.

2. METHODOLOGY

The aim of this research is to analyse the current trends in the provision and the selection of private rented student accommodation and their implications for fuel poverty in seven EU countries. It is conducted in the context of the SAVES2 H2020 funded project [6] that is attempting to help students to minimise their exposure to fuel poverty. In order to capture the views of the key stakeholders in the sector, landlords and tenants were approached to participate in quantitative (questionnaire survey) and qualitative (focus group/interview) research.

From the perspective of the *landlords*, the questionnaire survey and focus group included questions on their perceived importance of the energy efficiency of their property, their motivations to improve the quality of their property and their experience with students as tenants. From the side of the *tenant* their thoughts about energy efficiency, the drivers of housing and appliance choices, and the availability of financial motivations (i.e. subsidies) for the selection of better performing homes or appliances were investigated.

Data for students were collected between December 2017 and January 2018 in order to be reflective of fuel poverty conditions in their home (to cover some of the colder months of the year). Data for landlords were collected between October 2017 and January 2018.

Channels used to disseminate the research questionnaire included students' unions, regional and national landlords' associations, universities, local students' lettings agents and private rental agencies. Overall, 403 valid landlord and 1003 valid student responses were received from Cyprus, Greece, Lithuania, Ireland, Romania and Bulgaria in addition to the 2,509 students that participated in the NUS-UK 'Homes Fit for Study' research [5].

3. RESULTS

Students from the seven participating EU countries reported how energy was considered when finding a property and then living in rented accommodation. Some of the key findings from the student survey included:

- Cost of rent; location and convenience, condition of accommodation and size of accommodation were the main accommodation selection criteria.
- In Ireland (60%), Romania (48%), Cyprus (34%), Greece (33%), Lithuania (31%) and the UK (31%) a significant share did not receive an Energy Performance Certificate (EPC) for their accommodation either upon or without request.
- In almost all countries a high share was feeling a bit or much colder in their accommodation than they would have liked (i.e. 66% in Ireland, 56% in the UK, 48% in Greece).
- In all countries a considerable share reported damp or mould on walls or ceilings in their current accommodation (i.e. 38% in the UK, 28% in Greece, 19% in Cyprus).
- Significant proportions were feeling miserable (i.e. 44% in Bulgaria, 40% in the UK, 32% in Ireland) or anxious/depressed (i.e. 30% in the UK, 27% in Ireland, 21% in Cyprus) due to the poor housing conditions.

From the landlords' perspective key findings included:

- In Cyprus and Lithuania only 17% and 11%, respectively, provided an EPC to their student tenants.
- In most of the countries, focus group participants were unaware of financial incentives/grants for energy efficient renovation.
- In all countries, less than 22% had a smart energy meter or a smart thermostat in their property.

4. CONCLUSIONS

Fuel poverty is a significant socio-economic problem which disproportionately impacts upon people living in the private rented sector. Many students fall into this category and they are an under-supported group of the population – it almost seems that living in a poor quality property is treated as a 'rite of passage' for students. Evidence of student experiences of living in the private rented sector demonstrates a range of direct and indirect implications of living in a cold home. In particular, the impacts on the physical and mental wellbeing of students living in cold homes are alarming/troubling/disconcerting. Understanding the contextual situation of private-rented accommodation in seven EU countries can enable the identification of specific recommendations to help reduce the exposure of students to fuel poverty.

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A STUDY OF BEHAVIORAL AND SOCIO-ECONOMIC FACTORS INFLUENCING THE WILLINGNESS TO MONITOR THE ENERGY USAGE BY THE RESIDENTIAL CONSUMERS

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Keywords:, smart metering, smart-metering platform, environmental attitudes and behaviors, monitoring of energy usage, consumers, adoption, survey

1. INTRODUCTION

In Wroclaw, the capital city of the Lower Silesia region in the south of Poland, in years 2015-2017 the local DSO has installed smart meters (SM) at all the households. Apart from SM, the households have obtained access to the information about their energy consumption via **smart metering platform**: *e-licznik*, available also for smartphones and tablets. Consumers may also receive alerts when the aimed energy consumption level is exceeded. We assume that installation of SM at Wroclaw households and getting access to *e-licznik* could be an incentive to raise awareness, willingness **to gather knowledge about energy consumption and ways of better control over it and its conservation**. Based on the literature, we assume that acceptance and usage of SM platform is a phase-process as many other adoption of eco-innovation examples such as using green public transportation [1] or green energy [2].

Within this survey we apply **the stage model of self-regulated behavioral change (SSCB)** to foster consumer's usage of SM platform, which is equivalent to monitoring their own consumption patterns [1]. According to this model a decision to engage in a given behavior is a gradual process and consumers in different stages require different means to proceed to the next one. In case of adoption of *e-licznik*, the consumers can be in: (1) **predecisional stage**: "I never use an *e-licznik* platform. I feel content with this behavior and I do not see any reason to change it"; (2) **preactional stage**: "Currently, I sometimes use an *e-licznik* platform. However, I would like to monitor energy consumption more frequently, but I am not sure whether and how I can achieve this goal"; (3) **actional stage**: "It is my firm goal to organize my everyday activities so that I monitor energy consumption at my household via *e-licznik* platform. I exactly know how to achieve this goal, I just have to put my plan into practice"; (4) **postactional stage**: "I often monitor energy consumption in my household via *e-licznik* platform. I will maintain this behavior throughout the next months and might even intensify my efforts".

2. METHOD

In March 2018 residential consumers in Wroclaw (N=500) were interviewed by a professional polling agency. The questionnaire consisted of a few blocks of questions regarding respondents' environmental attitudes and behaviors, knowledge about energy market, ways of monitoring energy usage at their households and their attitudes towards *e-licznik* platform. The data were statistically analyzed in the SPSS program. Below we present only some of the results.

2. RESULTS AND DISCUSSION

The sample **demographic characteristics** are presented below. A total of 62.6% of the participants are female. 52% of the sample are between 25-60 years old. 61.2 % declare higher education. Around 25% of participants report living in a house (detached, semi-detached or a terrace house). 43.6% of the respondents perceive the financial situation of their household (i.e. average income) to be on the moderate level (but even 20.4% believe that their incomes are higher than average). Mean of respondents' monthly electricity bill equals 125 PLN (=29 Euro).

Monitoring of energy usage: 25.5% of respondents do not monitor their energy usage at all (49% of those respondents are in predecisional stage regarding *e-licznik* platform, but surprisingly most of them declare at the same time the willingness of transition to preactional stage, i.e. by starting using *e-licznik* platform to monitor energy consumption). Among those who already monitor energy usage: 46.4% regularly check and analyze their electricity bills; 30.6% rely on the information from the meter; 3.6% already use *e-licznik* platform; 0.2% use home area network; 2.8% use in-home displays; 0.8% prefer a personal contact with the DSO (i.e. infoline). **Knowledge:** respondent's knowledge about energy market (issues like: smart grid, smart meters, renewable energy sources, the most energy intensive home appliances, typical electricity tariffs for residential consumers, etc.) was transformed into scores, where the maximum result equals 12 (mean = 7.12, SD=2.63). Knowledge is negatively correlated with predecisional stage ($|r|=0.155$, $p=0.008$) and positively correlated with actional stage ($r=0.149$, $p=0.11$). It shows that the willingness to monitor the energy usage increases with general knowledge and awareness about the energy market. **Environmental attitudes and behaviors**: Firstly, even 84% of respondents do not agree with the statement that the environmental protection is not important for them. Most claim that everybody can bring a lot for environmental protection through own behaviors. Secondly, environmental behaviors are positively correlated with actional stage ($r=0.094$, $p=0.035$). Finally, attitudes towards monitoring of the energy usage positively correlate with actional stage ($r=0.347$, $p=000$) and with post-actional stage ($r=0.250$, $p=0.000$) and negatively with predecisional stage ($|r|=0.210$, $p=0.000$). It is quite clear that the readiness to monitor usage of energy via *e-licznik* platform increases with the belief that monitoring of the energy usage is generally right (76.4% of respondents), with feeling good while controlling the energy usage (56.4%) or with feeling personal responsibility that everybody can contribute to the environmental protection and the increase of energy efficiency by monitoring household energy consumption (71.2%).

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POTENTIAL OF INTERNET OF THINGS TO ACT AS ENABLER FOR REDUCING ENERGY CONSUMPTION & CO2 EMISSIONS IN SWITZERLAND

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Keywords: Internet of Things, Energy Consumption, CO_2 Emissions

1. INTRODUCTION

The Swiss population decided 2017 to start implementing the Energy Strategy 2050 in 2018. A main part of this strategy is to reduce CO_2 emissions. This can be achieved by both increasing efficiency and reducing the consumed amount of energy as well as by substituting for fossil energy sources. A promising approach to facilitate energy reduction and increase efficiency may be offered by Internet of Things (IoT) applications supporting respective energy-saving behaviour patterns [1][2]. A study in the mobility sector yielded 30% of CO_2 savings due to reduced search travels for a parking space if the parking spaces are equipped with IoT sensors [3]. A further study yielded savings of 18% if waste collection routes are optimised with IoT sensor-equipped waste containers [4]. In the building context, especially in the heating sector, savings of up to 26% can be achieved according to Fraunhofer-IBP [5]. Often the exact framework of the study is not clear, and the measures taken cannot be evaluated in close datail. In this study, similar use cases in Switzerland equipped with IoT technologies were analysed. Two out of four cases deal with automatic heating optimisation. The other two address transport optimisation whereby one with reduced service traffic thanks to remote photovoltaic monitoring and the other one with reduced waste collection routes due to remote waste level monitoring of underfloor containers [6].

2. METHODOLOGY

All four use cases are equipped with sensors according or similar to the definition of IoT. To be able to quantify the CO_2 equivalent savings of each use case, the companies behind the cases provided pre and post installation data. Further, calculation was based on one hand on a previous in depth LCA study analysing the CO_{2eq} saving potential of an IoT equipped smart parking system [7] and on the other on further information, assumptions and a widely used adaption formula for weather adjustment. In the previous study the production of parking sensors had the greatest influence in all the impact categories studied, which is due to the electronic components. During the use phase, the power consumption of the display-board and gateways has a significant impact on the energy resources used. The end-of-life phase has little impact on climate change and energy resources. Therefore, only the production phase was considered in this study.

3. RESULTS: USE CASE SPECIFIC SAVING POTENTIALS

The relative CO_{2eq} savings for the heating optimisation are in the range of 18–19%. For remote photovoltaic monitoring, the savings are up to 6% and for the remote level monitoring of underfloor containers the savings could rise up to 22% if it is taken into consideration that waste not only needs to be collected in relatively dense populated cities with some limitation in route optimisation but as well in rural areas. The different savings cannot be compared with each other because they are use case specific: three out of the four use case types are very different. Furthermore, the absolute saving potentials cannot be based only on the relative high or low savings of the use cases due to their specific circumstances. The focus of the analysis was only on CO_2 equivalents and not on further implications which could occur by the use or manufacturing of the installed products.
The upscaling for the yearly savings in 2020 in Switzerland in the four use cases will be presented at the Behave 2018 conference as well. For instance, up to 0.3–2.3 Mt/y CO_{2eq} could be saved due to heating optimisation. An average Swiss passenger car emits 5t CO_2 equivalents within an annual travel distance of 15’000 km. This means that in the case of heating optimisation the annual travel distance of 60’000 – 450’000 Swiss cars could be saved.

4. DISCUSSION AND CONCLUSIONS

The heating optimisation based on pre and post installation data comes up with the most promising amounts of net CO_{2eq} savings. These technologies should be developed further until they become standard in heating controllers. At the current stage of technology, the investigated technology should be implemented for low-cost, fast CO_{2eq} savings gains. If the ultimate goal is to reduce as much CO2eq as possible until 2020 based on the four investigated use cases, it is worth considering the installation of additional heating optimisation systems. Finally, in all four use cases, the grey energy was negligible compared to the potential CO_{2eq} savings.

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On the effectiveness of choice architecture tools aimed at energy consumption – a systematic review

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Keywords: Behavioural Insights, Energy consumption, Review, Interventions

1. BACKGROUND AND STORYLINE

It is, by now, a commonly known fact that human activities are responsible for climate change [1]. These activities, and the shift to more climate-friendly actions, are mediated by psychological and social processes [2]. Research shows, for example, that even if an individual has pro-environmental intentions, they do not necessarily translate into actions [3]. Overcoming this intention-behaviour gap is of particular importance for policy makers in order to find ways to promote sustainable behaviour.

Given the weight of the energy sector responsible for global greenhouse gas emissions, a household's energy consumption constitutes an important target for behaviour change that could mitigate emissions. Building on insights from the behavioural sciences, new tools known under the umbrella term 'choice architecture' gain in importance as means available to policy makers to influence behaviour [4,5]. Ideally, an intervention causes strong effects, lasts over time and leads to positive spillover effects, changing other related non-targeted pro-environmental behaviours (e.g. recycling and water consumption) [6,7,8]. A recent review by Andor & Fels (2018) [9] verifies the effectiveness of choice architecture tools aimed at reducing energy consumption of private households, yet it finds that effect sizes vary immensely and testifies that long-term effects and spillover effects are scarce. Interventions that seem to be effective in changing behaviour in one context seem ineffective or counterproductive in other contexts. We argue that analysing the psychologically relevant context, the "behavioural micro context", and specifying behavioural processes prior to designing an intervention results in larger effects.

In this line of work, we try to explain the variance of effectiveness by going beyond the analysis conducted by Andor & Fels (2018). In the current work, we review the literature on choice architecture tools aimed at reducing energy consumption. Particular focus is given to the following criteria: (1) how concrete was the behavioural micro context defined (2) how elaborate are theories discussed, (3) were underlying behavioural processes considered, (4) was the behavioural micro context assessed before the intervention took place (5) and was the intervention adapted to the behavioural micro context.

2. METHOD

Our initial review is based on the literature used in a previous review by Andor & Fels (2018). We extend the literature review on psychological and economic publication databases, in particular PsycARTICLES, PsycINFO, PSYNDES, and EconLit. We limit our review to peer-reviewed academic journal articles. All studies are field experiments, using quasi-experimental designs. In order to be selected for review, the study has to include a pre-/post-test or control group design. We categorized selected studies and the applied measurements based on a taxonomy of choice architecture techniques [10]. In a next step we examined the theoretical and methodical sections of each paper based on predefined criteria such as the theoretical depth and qualitative pre-assessment of the context. We then looked at whether the design of the choice architecture tool was tied to the theoretical elaborations and/or pre-assessment of the context. To evaluate the effectiveness of interventions aimed at reducing energy use we considered whether behaviour change and/or reduction of energy use is reported. We also assessed whether long-term effects were examined by follow up data collections. Furthermore, we examined if the study reported or discussed spillover effects to other non-targeted pro-environmental behaviours such as water and gas consumption as well as waste production.

3. PRELIMINARY CONCLUSIONS

We come to the following preliminary conclusions that we plan to extend by further quantitative analysis:

- The behavioural micro context is rarely explicitly defined. The target behaviour and group is often just described vaguely. For example, it is unclear whether an intervention is aimed at single individuals (e.g. the household head) or a group of people (e.g. the whole family). Often it is imprecise whether an intervention aims to change a single behaviour (e.g. turning off lights) or several behaviours. It is seldom specified weather the intervention is meant to change efficiency behaviours (e.g. investment in new appliance) or curtailment behaviours (e.g. habit of leaving lights turned on when leaving the room)
- The theoretical depth of papers is often at a minimum. Theories frequently get mentioned but are not elaborated in detail. Papers often focus on describing interventions and their potential effects, rather than tying interventions to theoretical considerations about behavioural processes and behaviour change.
- A lot of papers tend to over rely on previous studies and tend to blindly “copy & paste” choice architecture tools without adapting them to the specific behavioural micro context. Qualitative pre-assessments of the behavioural micro context and adapting tools to the context are scarce.

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TYPES OF ENERGY CONSUMERS IN OFFICES

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Keywords: User types, Office building, Office renovation, Workplaces, Energy efficiency

1. INTRODUCTION

The building sector accounts for more than one-third of the total primary energy use and has significant potential for energy saving [1]. However, various physical and social factors affect the energy performance of dynamic systems, such as the indoor climate condition, the building envelope, maintenance, building equipment, operation, and occupant behaviour [2, 3]. Particularly human factors contribute to a high variance in energy consumption [4]. The occupant is a major leading factor for energy use in buildings, since building systems run to provide comfortable working environments for occupants. Many studies have used kWh/m^2 /year to compare energy use of buildings [5]. However, the energy use also needs to be measured by occupancy schedule and density of building users [6-8] how many people work in an office; how many hours do they stay inside. The objective of this study is to investigate how much the energy use per person is different before and after office renovation towards energy efficiency, and to identify user types according to occupancy schedule and whether energy use differs between users.

2. METHODOLOGY

This research is based on a case study approach, analysing the energy efficiency performance in Dutch offices after renovation. Renovated office buildings have been analysed to evaluate the measures taken and the improvement of energy efficiency after renovation. Following, a survey has been held and is statistically analysed to identify occupant types based on occupancy schedule. The questionnaire contained 10 questions, consisting of 5 categories: main personal information, information about the personal workplace, occupancy time, break time, and the type of space available for breaks (Fig2). Four renovated offices were selected as case studies. The case study offices have a high energy efficiency performance with energy label A (Energy Performance Certificate based on EPBD directive). The questionnaire was distributed to 615 employees from the four cases. 554 of people who started the survey completed the questionnaire, corresponding to a 90% respond rate.

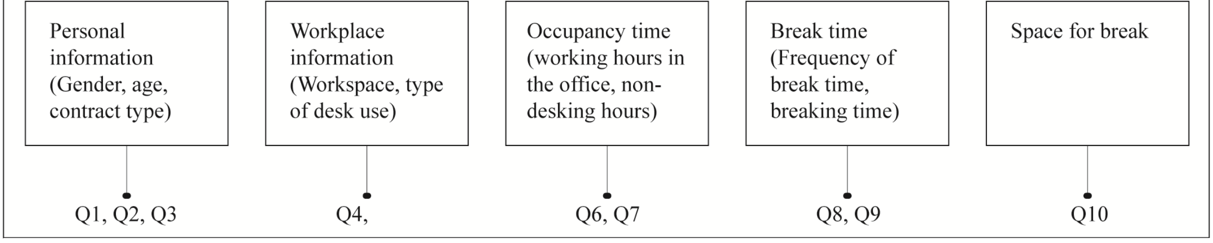

Figure 1 Schematic overview of questionnaires to identify occupancy pattern

3. RESULTS

Based on the outcome from the statistical analysis (using SPSS), occupant types of offices were defined. First of all, the data from the questionnaire were split into two groups of office occupants, depending on their employment contract type according to working hours, before conducting a two-step cluster analysis. This way, more precise occupant types can be generated than with merged contract groups. The results show that there are five occupant types in offices; three types of full-time occupants and two types with a part-time position. Type A and B are the people who work 31 – 40 hours in the office, and C works 20 – 30 hours per week. Of the full-time occupants, only type A spends the break time outside of the office whereas the other two types stay in the office (canteen). Type A and B have their own desks, but type C chooses their workspace randomly inside the office. Type D and E are the part-time contract employees who work 20 – 30 hours per week. Type D occupants do not have a fixed working desk, and they take a break outside of the office. Type E occupants have a fixed workspace (own desk), and they are likely to spend their break time in the canteen. Interestingly, all types take 30 minutes break time per day, next to their lunch break. Timewise, two groups were identified. Besides one-hour lunch time, one group tends to have three shorter breaks for 10 minutes each, and the other group has one break of 30 minutes.

Table 1 Energy consumption according to user types

User types	A	B	C	D	E
Energy use (kWh)	16.64	17.92	12.8	11.52	12.80

Based on the user types, distribution of energy use per person shows different figures. In average, people consume approximately 14.35 kWh per person in renovated offices and 22.92 kWh per person in non-renovated office. 8.57 kWh of energy use per person decreased after renovation. Table 1 show the energy use data applied the user types into energy consumption pattern in renovated cases. Thus, by using energy footprint of user types, we can predict the building energy consumption in an office renovation process.

4. CONCLUSIONS AND DISCUSSION

Occupants affect building energy use. Before we can understand occupant behaviour and energy using patterns, it is important to identify general occupant types. The occupant types which are clustered by survey explain occupancy patterns and occupancy hours of the office users. The outcomes of this research show the correlation between the energy use in renovated offices and the type of office user. The methodology used has proved to be useful to investigate occupant behaviour and user satisfaction alike studies.

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USING A SCENARIO-BASED METHODOLOGY TO ASSESS USERS' REQUIREMENTS FOR FUTURE THERMAL ENERGY STORAGE SYSTEMS

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Keywords: user centred design, thermal energy storage, user requirements, scenario-based game, vignettes

1. INTRODUCTION

Across the UK, forward-looking government policies are pointing towards the development of new, more sustainable and efficient technologies to meet the target of reducing 80% of greenhouse gas emissions by 2050 [1]. To realise this ambitious target, future energy systems are likely to rely heavily on intermittent energy generation and thermal energy storage. To design future socially, technically and economically viable thermal energy storage systems, a fundamental aim is to understand users' attitudes towards energy storage. This paper takes a user centred design approach to understand the users' requirements for future thermal stores for domestic heating and hot water systems by developing and assessing the effectiveness of innovative methods of requirements capture. An exploratory design game, the *Energy Game,* was developed and employed, aided by vignettes, to introduce users to the notion of future energy generation and identify key barriers and challenges to deployment and adoption within UK households. The inclusive nature of the game aims at enhancing users' input into innovation and encourages them to contribute to the co-design of future energy storage systems. This research study was conducted as part of the i-STUTE End Use Energy Demand centre.

2. METHODOLOGY

Data were collected from 10 families with mean household income £40,000–50,000, diverse educational background and hot water systems that included hot water tank, combination boilers and PV systems. The data collection proceeded in two steps; an unstructured interview during which participants were introduced to the game and real-life scenario: participants were asked to put themselves in the situation of the 'Little People'- a family living in the future represented by vignettes [2] and complete a series of hot water and heating-related tasks using a timeline tool (Step 1). The timeline tool was constructed for the purposes of the current study and represented a typical day in which the home is likely to be most occupied e.g. Saturday. Schematic representations served to visualise the daily hot water family routine and the hot water tank/store (Figure 1). Then, a semi-structure interview was conducted to explore users' views towards future energy storage and proactively engage them in the co-design of a more efficient system in order to maximise adoption (Step 2). The use of the scenario-based game methodology has been considered an effective way for contextualising occupants' attitudes towards future systems as it allows users to envision interactions and functions leading to more suitable, valuable and environmentally friendly technologies [3]. The *Game* was developed from previous work that examined the use of creative methodologies to encourage user involvement in design [4, 5]. NVivo, qualitative data analysis software, was used for the data coding and identification of themes. Data from the interviews were analysed using a combination of inductive [7] and deductive approaches [8].

Figure 1. Illustration of the scenario-based game.

3. CONCLUSIONS

The use of the *Energy Game* elicited a mixture of reactions and user requirements. The introduction to the game and potential future energy generation made users more energy aware (n=3) and helped them appreciate the environmental benefits along with the cost efficiency of using a thermal energy storage (n=3). The use of schematic representations and visual information, specifically, the ability to see inside the hot water tank (n=3) and awareness of the upcoming tasks (n=2) seemed to be essential for participants when making decisions for either completing or postponing a task. Also, through the *Energy Game* it was evident that the majority of the participants were concerned about the inconsistent energy generation (n=4) and the inconvenience of the system (n=4). Therefore, to overcome these barriers of adoption, key requirements for the design of future energy efficient systems and appliances are, feedback on energy use and consumption (n=4), information on the cost of hot water use (n=2) and embedded features that would help occupants reduce consumption (n=2). The creative scenario-based game developed for this paper proved to be an insightful avenue for offering a glance into the future allowing users to envision future circumstances, their usage and interaction with future technology.

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ENERGY POVERTY IN RURAL AREAS OF TAJIKISTAN

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Keywords: Energy poverty, Energy ladder, Energy stacking, Energy services, Tajikistan

1. INTRODUCTION

The implications of energy poverty on people's livelihoods are large and varied. To capture this complexity theoretically, the concept of *energy ladder* has been developed to illustrate energy poverty in terms of efficiencies of energy sources used by people with different socio-economic statuses to meet their household energy needs. It is expected that households move up the "ladder" from wood to coal to electricity, as their affluence increases. It is assumed that households inherently prefer "modern" or "advanced" over "traditional" fuels. The rationale is that modern fuels (e.g. liquefied petroleum gas, electricity) are more energy dense and "efficient" in delivering energy services than are traditional fuels (e.g. wood, dung) [1]–[3]. The literature on the subject has evolved over the past three decades, with the *energy ladder* model prevailing in the studies in the late 1980s through the early 1990s and, then, an alternative *energy stacking* model gaining ground since late 1990s [4]. The latter suggests that households use multiple fuels, adding new fuels on top of existing ones, and the relative use of each fuel is context-dependent [4]–[8]. Although this model helps to show the actual use of energy by households, it falls short of explaining why households use energy the way they do. In other words, the diversity of needs and plurality of energy options that can be used to address those needs are not taken into account.

2. METHODS

To address the shortcomings of existing models the *energy services* approach provides a compelling alternative. Energy services are divided into three broad categories: *energy for households*, *energy for earning a living* and *energy for community services*. The energy services approach requires that we first understand the energy needs, and then consider the options to address those needs [9].Adapting the *energy services* approach, a representative survey of 386 households was conducted in Khatlon region of Tajikistan to better understand the scope of energy poverty in rural mountain areas.

3. FINDINGS

Although affordability and willingness to pay were important consideration, the study did not support the inverse relationship between household's income and energy use, as postulated by the *energy ladder* model. In fact, households use a variety of energy sources, including electricity, wood and dung to satisfy their various energy services, including lighting, cooking, heating, cooling, information and communication, and mobility. Indeed, the multiple use of fuels found in the study area suggests an *energy stacking* model is at work in rural areas. However, beyond this simple model, the *energy services* approach provides a more nuanced understanding of why households use multiple fuels. The main reason is that each fuel is used for a different purpose, such as cooking and baking, space and water heating (see Table 1) as well as cooling, information and communication, etc. Moreover, the use of fuel critically depends on the availability, affordability and reliability of energy sources. When any of these qualities is lacking, households adopt multiple energy sources to increase their options.

Table 1: Comparison Of Daily Biomass Use For Thermal Energy Services

	Min (kg)		**Mean (kg)**		**Max (kg)**	
	Wood	*Dung*	*Wood*	*Dung*	*Wood*	*Dung*
Cooking	0.5	1	7.2	4.4	20	14
Bread baking	0.4	0.5	12.6	9.02	40	20
Water heating	0.5	1	7.9	6.5	30	28
Space heating	0.7	2	13.2	9.2	60	50
Sum of all services	3	3	37.2	22.7	130	75
Combined biomass	16		57.7		132	

4. CONCLUSIONS

This study adapted the *energy services* approach of Practical Action [9] to better understand the nature of energy use in rural areas of Khatlon region, Tajikistan. The approach complements the theoretical model of *energy stacking* and provides further insights into the multiple fuel strategy employed by many rural households. The alternative model of *energy ladder*, however, does not find support in this study. Overall, the findings from this study can inform energy policy in rural areas in that energy provision should be considered in terms of the *services* that it enables. Put simply, satisfaction of the needs should take precedence over a narrow focus on providing merely a source of energy (which is usually electrification). When the focus shifts from sources to services, alternative technologies and options can be evaluated in their effectiveness to provide the needed services. A package of reinforcing measures to address the challenge of energy access may also include improvements in efficiency, reduction in demand, and expansion of supply of electricity through grid. Ignoring the services would jeopardize the hopes of alleviating energy poverty in rural areas. Ultimately, the role of households and their communities should not be overlooked in addressing their energy challenges.

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Developments of charging infrastructure provision by Swedish housing cooperatives

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Keywords: Electric vehicles, Charging infrastructure, Housing cooperatives, Behavioural change

1. INTRODUCTION

The availability of charging infrastructure is a pre-requisite for electric vehicle (EV) adoption, which is one of the ways to make the transport system more sustainable. A large part of the population in Greater Stockholm, as in most other metropolitan areas around the world, rents or owns an apartment as opposed to a single family house. In most cases, these people do not have dedicated parking places that could be equipped by an electric vehicle charging point. Therefore, electric vehicle adoption for this group implies relying on publicly available charging infrastructure. In Sweden, as in many other countries around the world, housing cooperatives own many apartment buildings, including parking places either in parking garages or on private streets. These housing cooperatives could provide charging infrastructure for their tenants, thereby facilitating electric vehicle adoption for many people living in an apartment.

2. PROBLEM STATEMENT AND OBJECTIVES

Policy makers in Sweden are currently stimulating housing cooperatives to invest in charging infrastructure. For example, subsidies can be applied for by cooperatives covering up to half of the investment costs of charging infrastructure [1], and in Stockholm, information and awareness campaigns (workshops, presentations and a website) are being organized by the municipality to increase the number of housing cooperatives providing EV charging infrastructure. However, more insight is needed into the decision making processes driving this provision.

The objective of this research project is to get more knowledge about the current state of charging infrastructure provision within the properties of housing cooperatives in Sweden, as well as getting more insight into the reasons why certain cooperatives provide or are planning to provide charging infrastructure, while other cooperatives are not planning to provide this. Besides one study in the US [2], little is known about the decision making processes of housing cooperatives with regard to the provision of electric vehicle charging, although they could be a key player in electric vehicle adoption.

The research questions for this study are the following:

- How is the current state of electric vehicle charging infrastructure within the properties of Swedish housing cooperatives?
- Which future plans do Swedish housing cooperatives have for providing charging infrastructure?

- What are the reasons for (not) providing or planning to provide electric vehicle charging infrastructure?
- What are the perceived financial consequences of providing EV charging infrastructure?

3. METHODOLOGY

A web-survey has been sent to in total 2,000 housing cooperatives in Sweden: 1,000 of which in Greater Stockholm, 500 in the metropolitan area of Gothenburg and 500 in the region of Scania (with Malmö as the biggest city). In total, 305 respondents (15%) answered to the questionnaire. However, 35 cooperatives did not have any parking places under their disposal. Therefore, the analyses are based on 270 respondents. Constructs from the Transtheoretical Model of Change [3] have been used as a framework in this study. Descriptive statistical analyses have been conducted, as well as hypothesis tests. In a later stage, multivariate methods such as regression modelling and factor analyses will be conducted. Environmental awareness, perceived solidarity within the housing cooperative and resistance to change will be investigated using Likert-scale indicators.

4. RESULTS

The provision of charging infrastructure is a hot topic among housing cooperatives in Sweden. Despite the fact that currently 17% of the respondents is providing charging infrastructure, another 47% is planning to provide charging infrastructure. 76% of the respondents think that it is a comparative advantage for housing cooperatives to have charging infrastructure for their tenants. Moreover, more than one quarter (27%) of the respondents thinks that it is easier to sell apartments because of the presence of charging infrastructure for electric vehicles. When comparing groups in the different stages-of-change towards charging infrastructure provision, it appears that knowledge about the potential incentives increases the closer the housing cooperative is to adoption of charging infrastructure (ANOVA; p-value= 0.005). Against the expectations, steering groups of these housing cooperatives having planned or implemented charging infrastructure estimate the environmental awareness of their members to be relatively lower (t-test; p-value = 0.042). Regarding the challenges hampering large scale deployment of EV charging infrastructure, aspects such as investment costs, but also the payment model or lack of knowledge about appropriate number and type of charging boxes, have to be resolved.

5. CONCLUSIONS

The interest from Swedish housing cooperatives is promising. Nevertheless, many challenges have been identified hampering a large scale deployment of EV-charging. Besides cost issues, there are practical challenges to be solved. Assistance in this process, for example in workshops or information meetings, is considered to be valuable.

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What are the challenges to include the trade, commerce and service sector in contributing to the energy transition - Lessons Learned from Germany

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Keywords: Grid service; behaviour; flexibility; trade, commerce and service sector;

EXTENDED ABSTRACT

The long-term energy transition heavily relies on renewable energies which make the power generation more volatile. For instance, at certain times electricity from regenerative sources is abundant, while at other times fossil peak-load power plants have to generate electricity to match demand [1]. On the one hand, this poses new challenges for the grid infrastructure of a future energy supply system; on the other hand, this implies several stakeholders to act differently. One possible solution is to provide energy demand flexible and on short term for a required energy system [2]. This flexible integration of electricity is referred to as a *grid service*. The aim of a *grid service* is the efficient integration of large proportions of volatile renewable energy into the energy system. For instance, a *grid service* can take place as demand response in form of load shifting or load reduction. It refers to the temporal change of end consumers' usual electricity use pattern mostly through monetary incentive payments [3]. Especially in the trade, commerce and service sector demand response can play a major role due to higher cost effectiveness and the possibility to predict the internal load management [4]. While many projects have focused on private households to provide flexibility for the grid, we assume that the trade, commerce and service sector has a much higher potential to contribute, since in 2013 the service sector made up 29 % of the overall electricity consumption in Germany [5]. According to the Dena study [6], the economic potential of demand response in the service sector is 5.7 TWh and 12.2 TWh in the industry sector. However, demand response still does not play an active role in this sector yet. To better understand the reasons, this paper investigates what factors motivate or hinder decision-makers of participating in implementing a *grid service*.

Within the research project "FlexControl" Fraunhofer ISE carried out a German wide online survey with a semi-structured questionnaire. In total 93 representatives of the middle and upper management of the management, building and energy field participated. About half of the respondents work in the service sector, while the remaining participants are distributed in the commerce, catering, industry, education and health care. The aim of the survey was to determine the willingness of these actors to introduce a *grid service* and the factors that increase or weaken the will to participate. Part of the questionnaire is based on the Technology Acceptance Model (TAM) [7] and includes factors such as confidence in own competences, social responsibility, the wish to stay in control of the in-house building management, and corporate hierarchy. The other part of the questionnaire includes items to describe the physical characteristics of the interviewed companies (size, number of employees, etc.), as well as items concerning a possible future *grid service* strategy. Further, questions involved economic, ecologic and social issues related to the use. They are analysed in a descriptive way.

The results confirm what we described earlier, that a *grid service* is not yet established in any of the sectors. Therefore, the focus of the questionnaire addresses the willingness to implement a *grid service* in the future. About 25% of the participants have concrete plans to implement a *grid service* and almost 50% of the respondents are discussing intensively the introduction of a *grid service* on a

management level. Results show that the willingness to implement a grid service is reduced by 1) a steep hierarchical business structure 2) the desire of companies to completely regulate and control their energy and building management internally 3) the concern of risks. The most commonly stated fears were losing energy security, losing the control over own facilities and dissatisfied users because of a loss of comfort (e.g. room temperature). Furthermore the respondents were worried about the - so perceived - potential inefficiency of a *grid service,* and increasing temporal as well as personnel costs. These fears reveal a huge variety of possible reasons that could challenge active participation in the structural change of the energy system.

While none of the participating organisations have yet applied *grid service*, the results show that the tertiary sector has a positive attitude towards it. Factors that support the willingness to implement *grid services* are: 1) the concern about climate change 2) a corporate strategy characterized by innovation and readiness to take risks and 3) the willingness to assume responsibility for the energy transition. These strengthening factors are based on intangible assets, which might be surprising in the context of business oriented companies: social benefits such as the contribution to the energy transition, the promotion of renewable energy, the wish to secure the regional electricity supply and the public perception of the company's commitment are crucial values in decision-making. There is a clear willingness to take a responsible role in the transformation of the energy system and the will to invest is not necessarily linked to high amortization expectations. This implies that the energy transition should not only be considered from a purely savings perspective, but also in the context of social responsibility and business structure. The implementation of a policy framework which incentivizes grid service through social benefits could encourage the tertiary sector.

The results have shown that *grid services* can be a possibility for companies to actively participate in the energy transition. To encourage future investment and active participation the challenge of high perceived risks must be overcome. In order to further strengthen the willingness to implement *grid service* in the trade, commerce and service sector, politics and energy providers have to adapt more positive framework conditions. The focus should be on increasing the public perception of a *grid service* as a positive impact on the energy transition. This can be implemented through: 1) the development of a nationwide certificate labeling companies already using grid service. That allows companies to position themselves as sustainable and thus attract new customer groups 2) addressing technical issues proactively could prevent the fear of companies to lose control over their own facilities 3) a regulatory transformation of the electricity market is necessary in order to strengthen the market for flexibility products at various network levels. As the company's management structure has a significant impact on the openness to adapt new internal processes, this is certainly another change process that should occur to favor grid services.

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TOWARDS A 'SMART' ENERGY CULTURE? EVALUATING THE INFLUENCE OF SMART METER FEEDBACK IN A CANADIAN CASE STUDY

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Keywords: In-home displays (IHDs), energy culture, smart grid, consumption profile, clustering, conservation and demand management (CDM).

1. INTRODUCTION

The introduction of the smart grid increases the feasibility for empowering electricity consumers through real-time consumption feedback, particularly through in-home displays (IHDs). However, it is critical to assess whether real-time feedback through IHDs shifts energy practices and norms towards both a 'smart' and 'sustainable' energy culture. This study investigates the influence of a large-scale implementation of IHDs on electricity consumption in Ontario households (n=5274) compared to a control group without the IHD (n=3020). This study utilizes thermal sensitivity and set points, as well as household electricity consumption profiles, to cluster households into different sub-cultures of consumption. Further, these clusters are used in a multiphase analysis to determine whether: 1) the IHD influenced the overall population; 2) different sub-cultures of consumption responded differently to the real-time feedback; 3) household segmentation provided smart grid policy insights for consumer engagement. Quantitative assessment of energy practices, norms and sub-cultures utilized in this study develops the application of the Energy Cultures Framework, and further shapes this framework by studying the influence on a 'smart' energy culture [1], [2].

2. METHODS

A multiphase analysis was used in this study to cluster the households and assess the influence of the IHD on the population as well as to identify cohorts of similar households. First, consumption and climate data were collected and aggregated to five periods related to Ontario's Time-of-Use periods. Second, households were characterized based on their load-shape profiles and thermal properties (heating, cooling, heating/cooling, non-thermal) based on thermal sensitivities and consumption during the week. The Aikake Information Criterion corrected method was used to select the most appropriate model. Third, households were clustered using K-Means clustering into thermal archetypes (heating, cooling, heating/cooling clusters) and behavioural archetypes, based on weekly consumption patterns (behavioural clusters). Further, these households were also combined into archetypes to categorize thermal and behavioural properties together (thermo-behavioural clusters).

Fourth, consumption of the control and sample group was standardized to reduce systematic differences to ensure they were appropriate for comparison and analysis. Fifth, linear regression analysis assessed the IHD at the overall population-level and cluster-levels. This assessed the effect on four periods of consumption: 1) the overall average consumption; 2) the time-of-use consumption; 3) weekend consumption; and 4) weekday consumption.

3. RESULTS

Through the clustering process, several sub-cultures of consumption were identified: 6 behavioural clusters, 13 thermal clusters, and 77 thermo-behavioural clusters. Following the multiphase analysis, several highlights can be drawn regarding the influence of the IHD on different segments of the households within the study. The IHD had no influence on the overall participant group, consequently providing strong opportunities for segmented analysis. Different sub-cultures responded differently to the IHD; however, no clear patterns of conservation or peak shifting influences were identified. Therefore, the IHD had limited influence on the behavioural and thermal clusters. When combining thermal and behavioural contexts, different sub-cultures also responded differently. Five of the 34 influenced clusters highlighted favourable changes. Out of these notable clusters, heating cluster households experienced the most significant peak consumption changes. In particular, households with high heating sensitivities and who consume most of their energy during evening periods, showed clear signs of peak consumption reductions in conjunction to the IHD installation.

4. CONCLUSIONS

Applying the energy cultures framework provides a unique opportunity to study household segments and their reactions to an IHD in an Ontario context. This study identifies sub-cultures of consumption based on thermal models and behavioural load shapes relevant to central Ontario homes. Furthermore, this study compares the influence of IHD installations in 5274 homes to a control group of 3020. Following the analysis, it was clear that different sub-cultures of consumption responded differently to the real-time feedback; however, limited signals of peak shifting and conservation were evident. Five thermo-behavioural clusters in this study were particularly notable. It is evident that households inclined to reduce peak consumption had high heating sensitivities and consumed most of their energy during evening periods.

As a result, this study provides 4 key policy insights: 1) stresses the importance of target market and segmentation in the roll-out of conservation and demand management programs; 2) emphasizes the inclusion of additional engagement mechanisms alongside information and feedback in smart grid engagement strategies; 3) highlights the influence of behavioural and thermal preferences in predicting intervention responses; 4) showcases the potential for utilizing consumption data to understand consumers and their preferences in the absence of socio-economic data; and 4) extends the Energy Cultures Framework by its clustering methodology utilizing both consumption and climate data. Therefore, this study brings policy insights into the delivery and design of IHD programs and targeting particular sub-cultures of energy consumers in the smart grid.

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SOCIAL FACTORS CONTRIBUTING TO THE SUCCESS OF CYCLING UPTAKE INTERVENTIONS

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Keywords: Behaviour Change, Cycling Adoption, Social Inclusion, Belonging, Cycling Skills

1. INTRODUCTION

Changing transport behaviour to low-carbon active transportation options from carbon-emitting vehicles is challenging. In Canada, transportation emissions remain the second largest emissions sector and the only one to continue to increase in the decade from 2005 through 2015 [1]. Cycling interventions to encourage adoption have gained popularity in recent years, though few are rigorously evaluated [2,3,4]. Generally, such programmes have focussed on individual behavioural change and psychological theories like the Theory of Planned Behaviour [5]. More recently, however, interventions recognizing the social context of would-be cyclists have gained adherents [6, 7, 8, 9].

This presentation describes a series of socially oriented interventions directed towards both recent immigrants and longer-term residents in Toronto and the nearby City of Brampton, including in suburban areas with little cycling infrastructure and low cycling mode share. The surprising outcomes of these interventions have included a strong increase in the frequency of cycling for transportation, despite the constancy of attitudes towards cycling, the rarity of cycling and bike parking, bike lanes or designated cycling friendly streets, and the dominance of automobile supportive design in these neighbourhoods. To better understand the mechanism permitting such strong uptake, our analysis focuses on the social motivators for participation, social outcomes of the programs and the influence of social factors on behaviour change. Our findings have strong implications for future interventions, including the design of outreach, program activities and ongoing social support for low carbon transportation behaviours.

2. THEORETICAL PREMISE

Individuals do not make behavioural changes in a vacuum. Rather, social interactions at the personal, neighbourhood, and community level interact with individual knowledge, skills and experience of the environment to produce behavioural changes [10,11,12]. Personal interactions include the communicated perceptions of family members, friends and acquaintances. Neighbourhood interactions can include perceptions of general social interactions in the immediate vicinity of a participants' home location. Community interactions can include perceptions that certain actions are rare or strange in the community. This analysis evaluates whether these three tiers of social interactions: personal, neighbourhood, and community, impact how individuals respond to cycling uptake interventions. Further, this analysis will evaluate whether cycling adoption changes are impacted by the development of new social relationships over the course of programming.

3. DATA & METHODS

Data came from intake and exit surveys completed by participants in four mentorship based multi-month cycling programs in 2015, 2016 and 2017 as part of their participation. The data from the four programs were combined for a total n of 150 matched surveys. Questions that related to bicycling frequency and social interactions were included in this analysis. Regression analysis was used to identify relationships between the dependent variable-level of change in cycling behaviour and the independent variables-change in response from entry to exit on questions related to perception of personal, neighbourhood and community attitudes.

4. FINDINGS

These opt-in interventions had considerable success in shifting participants' transportation patterns to cycling. While attitudes and perceptions of peer support changed little between pre and post surveys, the desire to make social connections and improve neighbourhood awareness and belonging were clear motivators for cycling adoption. Increases in the participants' number of new social connections was positively correlated with increases in cycling uptake at the 95% confidence interval, while perceptions of established friends and family had no statistically significant influence. Perceptions of personal, neighbourhood and community factors had no statistically significant impact on behaviour. Increased knowledge of the local community and an improved sense of belonging in the community were ranked at the same level as increased cycling skills as received program benefits.

5. DISCUSSION AND CONCLUSIONS

It appears that cycling adoption is not only motivated by transportation related needs, or financial considerations, but also and possibly even more importantly, by social factors. The focus of cycling adoption programs should consider the most important motivators for participants, to ensure maximum attraction and effectiveness. Moreover, in Canada at least, suburban populations least likely to cycle currently also suffer most from lack of access to other forms of transportation and from chronic health conditions related to inactivity like diabetes. Taking social factors into account can increase the success of behaviour change programs to encourage active transportation and can simultaneously improve social inclusion and health outcomes.

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ASSESSING CONSUMERS' PERCEPTIONS OF ELECTRICITY USE: DOES PROVIDING REFERENCE POINTS HELP?

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Keywords: reference points; electricity use of appliances; accuracy of perceptions; energy feedback design

1. INTRODUCTION

Over the course of recent years, electricity companies have been installing smart meters combined with in-home displays, and other communications. However, feedback devices may fail to promote behaviour change if consumers do not understand what is being communicated. Also, consumers often find it hard to assess how much electricity is used by their household appliances. Providing a ‘reference point’ (showing how much electricity is used by another appliance, such as a single lightbulb) can be a simple yet effective strategy for improving the accuracy of consumers’ perceptions of appliances’ electricity use. Here, we examined whether the provision of one or more reference points (vs. none) improved participants’ (1) accuracy of perceptions of electricity use for specific appliances and (2) associated confidence.

2. METHOD

In a US online survey, 504 participants reported their perceptions of electricity use (in Watt hours) for nine different appliances (e.g. air conditioner, electric oven, dishwasher, coffee maker, freezer, refrigerator, laptop, TV and cell phone charger) as used over the course of one hour. These appliances were chosen because the majority of household in US use them on a daily basis. Participants were randomly assigned to one of five experimental conditions: (i) no reference point, (ii) a single low reference point (light bulb), (iii) a single high reference point (electric dryer), (iv) two reference points, one low and one high (light bulb and electric dryer) and (v) three reference points, including one low, one medium, and one high (light bulb, washing machine and electric dryer). Accuracy of perceptions was computed by taking the absolute difference between perceptions of electricity use and actual electricity use as estimated for each appliance individually. Official estimations of actual electricity use were taken from the literature. Participants' confidence in estimates about electricity use was measured on scale 1 ("not at all") to 5 ("extremely").

3. RESULTS

We examined participants' assessments of their appliance-specific electricity use as compared to the estimated actual use of those appliances over the course of one hour. We conducted a mixed-methods ANOVA to compare the resulting difference scores, with a within-subject variable for the nine appliances and a between-subject variable for the five different reference point conditions. We found that providing one or more reference points (rather than no reference point) influenced the accuracy of perceptions of electricity use across all of the appliances presented. Specifically, participants who received a single low (e.g. light bulb), or two or three reference points reported more accurate perceptions of electricity use for specific appliances than did those who received no reference point. The provision of a high reference point made no difference, perhaps because people tend to generally overestimate how much electricity is used by their appliances. Additionally, in conditions with two or three reference points, participants were more confident in their estimates and perceived the task as less difficult.

4. CONCLUSIONS

Our findings suggest that reference points play an important role in improving the accuracy of consumers' perceptions of electricity use across appliances, as well as their associated confidence. We discuss the importance of incorporating reference points in the design of effective electricity feedback for consumers.

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ENERGY MEMORIES – A NEW CONCEPT FOR UNDERSTANDING THE IMPACT OF HISTORIC EVENTS ON ENERGY CHOICES

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Keywords: Energy**,** Collective memory, Sites of memory, Behaviour, Energy culture

1. INTRODUCTION

In this article we present the research concept of the "Energy Memories", which we developed within the framework of the HORIZON 2020 project ECHOES, in order to open up an additional perspective on culturally different attitudes towards energy and energy behaviour in European societies.
By "Energy Memories" we understand the historical succession of collective experiences that reflect the societal/energy political developments and result in certain lasting attitudes towards energy within society.
The concept is based on the following theoretical approaches and aims at complementing them:
First, the Energy cultures approach as formulated by Stephenson et al [6]. “Energy Cultures” is a three-part arrangement of “Material culture”, “Energy practices” and “Cognitive norms”, where each component is understood as interdependent with the remainder. This model is influenced by systems thinking and cultural sociology/habitus [2], social practice theory [3], actor-network-theory [4], embeddedness in cultural processes [5] and socio-technical systems, e.g. [1]. However, “Energy Cultures” is a concept that does not explicitly take factors lying in the past into account, i.e. the “path” leading a society to the status quo of its energy culture, considering technical and societal aspects.
Secondly, it is based on the work on Collective Memories, reflected in publications of Halbwachs [7], Confino[8], Connerton[9] and Uekötter[10], investigating to what extent the general "orientation" or certain fundamental attitudes of a society towards a topic are shaped by collective experiences, and a culture of influence or forgetting.

2. RESEARCH APPROACH

The Energy Memories concepts adds to the Energy cultures approach the “historical pathway aspect”: “What political, social, cultural, technological “Key Events” of the past may be recognised as “Key impulses“ that produced – in a given society - a multitude of political, administrative, cultural and other consequences that still shape debates and practices today?”

Furthermore, the Energy Memories concept for the first time applies the “Collective Memories” focus on the energy theme, using Uekötter’s “sites of memory” definition that was developed for “environmental memories”.
The Energy Memories concept thus tries to capture and describe a) historic key impulses and it b) describes energy relevant attitudes, beliefs and practices that developed from that past impulses and may be observed these days, as (society-specific) “background noise”, becoming socialized and part of the cultural practices.
In the scope of ECHOES project, we analysed Energy memories and their underlying “Key Impulses” in five European countries.

3. CONCLUSIONS

Key impulses that had an impact on “Energy memory” differ widely among societies and can emanate not only from single events, but also from events that took place over a limited period of time (e.g. limited periods of political transition or socioeconomic stress) and were so intense that they shaped long-lasting practices, the social state and the situation in the energy sector.
At the conference, results from selected country studies as well as transnational findings will be presented.

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THE IMPACT OF THE SWISS CLIMATE POLICY INSTRUMENTS ON THE ENERGY CONSUMPTION AND GREENHOUS GAS EMISSIONS IN THE INDUSTRY AND THE SERVICE SECTOR: EVIDENCE FROM AN EX-POST EVALUATION OF MICRODATA

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Keywords: Energy consumption, Carbon tax, Emissions targets, Greenhouse gas emissions, Policy evaluation

1. INTRODUCTION

This paper empirically evaluates the impact of the Swiss climate policy mix introduced in 2008 on the energy consumption and greenhouse gas emissions of firms in the service and industry sector. These sectors contribute roughly to 35% of the final energy consumption and 30% of the emissions. To achieve the 2020 emission targets, the Swiss government employs various policy measures, including price-based instruments, such as emissions trading and the CO_2 levy, and non-price-based instruments, such as binding emission targets or building codes. Emission trading is mandatory for companies passing a certain emission threshold. Other measures are optional and allow for an exemption of the CO_2 levy.

2. LITERATURE

According to the latest World Bank report [1] 45 national and 25 subnational jurisdictions - representing about half of the global economy and 20% of global greenhouse gas emissions - are putting a price on carbon. Leu and Betz [2] give a detailed overview of ex-post evaluations of explicit carbon taxes. They discuss difficulties in implementing experimental designs with a proper counterfactual, noting that quasi-experimental methods such as “before and after”, “difference in difference” or “fixed effect” models play a dominant role in ex-post evaluation. The study by Martin, De Preux [3] covers similar issues regarding data and methods as addressed in this paper. The authors estimate the impact of a carbon tax on manufacturing plants using panel data from the UK. In their paper, they revealed that the climate change levy caused plants paying the full rate to reduce CO_2 emissions by between 8.4% and 22.6% more compared to plants that paid the reduced rate. Jakob, Rosskopf [4] investigate the impact of the CO_2 levy in Switzerland on emissions-related decisions of the companies. They have conducted an extensive company survey. Based on the survey results, they conclude that companies with high CO_2 emissions have reacted earlier than other companies. On behalf of the Federal Office for the Environment, two ex-post evaluations of the Swiss CO_2 levy were conducted [5]. The estimation results of the two models give upper and lower bounds of the CO_2 mitigation that range from 4.3 to 7.1 % in 2015.

3. MAIN RESULTS AND CONCLUSION

The impact of these energy policies on energy consumption is tested, using a representative sample of more than 22,000 firms in Switzerland, ranging from 1999 to 2016. Panel data regression models are applied in order to identify time-varying policy effects, such as increasing CO_2 taxes, and to isolate them from time-independent, unobserved firm-specific factors. Time trends allow us to capture technological progress. Controlling for economy wide effects including heating degree-days a measure for the economic activity or the real crude oil price, we conclude that Switzerland's energy and climate policy has a significant impact on the energy consumption in the industry and service sector. Figure 1 below shows the evolution of the CO_2 emissions, which have been, from 2008 onwards, taxed by the CO_2 levy. The vertical red lines indicate the different time points of the above-mentioned CO_2 tax raises. The straight lines represent the time trends of the evolution of the average energy consumption.

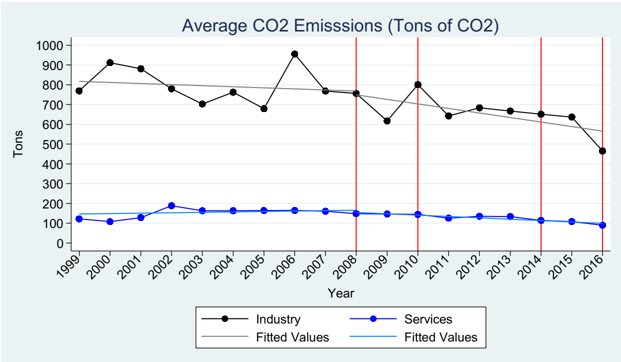

Figure 1. Average energy consumption of the sampled firms by sector between 1999 and 2016.

The analysis has shown substantial reductions in the CO_2 emissions for the average firm in the industry and service sector post-policy. The impact of the low CO_2 taxes of the first years was quite limited. However, after raising the tax to CHF 60/ton of CO_2eq in 2014, firms responded to this higher tax by intensifying their energy saving measures or by substituting towards lower carbon-intensive energy sources such as natural gas or wood. The study can be regarded as a first contribution towards an ex-post analysis of the effectiveness of the Swiss climate and energy policy instruments as a whole, but especially the CO_2 levy, in the industry and service sector, based on firm-specific data. Our results can assist governments to design and adjust policy instruments in order to meet the 2030 Paris goals.

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Exploring the Social Acceptance of Building Integrated Photovoltaics in Switzerland

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Keywords: Solar Energy, BIPV, Photovoltaic, Social acceptance

1. INTRODUCTION

The integration of photovoltaics in buildings is a rising field of action in the renewable energy sector and gaining political attention. Especially in view of the federal Energy Strategy 2050 with its goal of an increasing share of solar energy [1], PV technology will play an important role in the future. The so-called Building-Integrated Photovoltaic (BIPV) technology, where PV modules have the function of a building element such as a façade, a roof or shading, is a promising approach in this field [2].

Despite its huge potentials for achieving energy policy goals and the fact that we witness in the last decade an almost exponential growth in research dealing with social acceptance of renewable energy technologies (RET) [3], the social acceptance of BIPV has attracted surprisingly little attention. A rare example of research in this field is [4], who identifies the main facilitators and barriers regarding the market adoption of this innovative RET and classifies them into the product-specific, adopter-specific and the institutional ones. Despite providing very interesting and important insights in market acceptance of BIPV, [4] leaves questions regarding other two social acceptance dimensions in terms of [5] - socio-political and community acceptance - unanswered. Moreover, a rather new understanding of social acceptance emphasizes the importance of middle actors, who play a role “in diffusing innovative technologies and practices” [6]. Against this background, we focus in this study on i) community and socio-political acceptance and ii) middle actors perceptions of and their work towards the diffusion of BIPV. In particular, we shed light on following research questions:

- What are the main acceptance factors for community and socio-political acceptance for (BI)PV?
- What are perceived risks and how strong is the public acceptance of BIPV technology?
- What is the impact of different design propositions of an apartment building with BIPV on it’s acceptance?
- What are the main issues, challenges and chances regarding BIPV adoption among middle actors like stakeholders of the administration and community organisations

2. METHOD

An online survey in spring 2017 with 552 persons from the German-speaking part of Switzerland, which were representative in terms of age and sex, was conducted. The questionnaire included amongst others items on general acceptance, individual acceptance factors found in the literature and risk perception associated with BIPV in general, as well as a set of questions regarding attitudes towards specific building design prototypes with BIPV (designed by EPFL-LAST). Furthermore one focus group interview was held with key stakeholders from the public administration and civil sector organizations of the city of Frauenfeld and canton Thurgau playing a role for the application of BIPV in real life.

3. RESULTS AND DISCUSSION

Acceptance of BIPV by the broad population seems to be rather high (mean=3.6, sd=.96, 1-5 Likert Scale), especially among persons with higher education level. Moreover, a large majority of respondents do not attach any risk to the technology (86.1%). However, the knowledge and experience level is still very low, which implies that the rather high general acceptance mentioned above could be fragile. Those few who identify some technology-related risks mainly refer to aesthetics ("optical disfigurement of the municipality"), heritage protection ("destroys the townscape") and grey energy ("manufacturing involves grey energy"). Environmental aspects are the most important acceptance factors followed by siting decisions. Furthermore, the importance of cost-effectiveness of the technology even for the people, who do not directly apply and benefit from it became apparent. The most important procedural aspect for acceptance was transparency; in contrast, participation in a BIPV application project was not of high importance.

4. CONCLUSIONS

The study reveals a rather high acceptance of BIPV in Switzerland by the broad public and a very willingness to support in the evaluated cantonal and local administrations. Above all, perceived positive environmental impacts of the BIPV technology is supportive for its acceptance. The associated risks need to be addressed, especially the use of grey energy (respective the energy payback time of the technology), concerns about impacts on health (above all electromagnetic radiation) and uncertainty regarding the disposal of old PV modules. However, most of the people do not see any risks in BIPV application. The question of siting in contrast is a more important topic for the public, as different sites are judged very diversely regarding their appropriateness for BIPV application. This has to be taken into account in the further diffusion of the technology. Furthermore, while people ask for transparency in the process of further BIPV application, they do not wish an active participation. Governance issues on the local level are crucial because actually local administrations have large freedom regarding the implementation of the federal or cantonal laws or regulations. Middle actors fear that the many aesthetically questionable applications of PV on buildings have negative impacts on the perception and diffusion of the new BIPV technology, as people mostly see the "bad" examples and not the new possibilities of PV integration in the building surface. Hence, they all agree that pilot projects with good designs might reduce this problem and that local and regional government need to take a role model function for buildings with BIPV.

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Train, Plane or Skype? Testing possible interventions to reduce flight emissions at Zurich University of Arts

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Keywords: air travel, travel mode choice, alternatives for air travel, travel booking service, environmental concern, video conferences

1. INTRODUCTION

Aviation emissions are an impactful factor on anthropogenic climate change (compare Gössling, 2002), with a rapid growth of the sector (International Civil Aviation Organization, 2017). At Western universities, air travel often accounts for the majority of overall CO_2 emissions (Le Quéré et al., 2015). Several universities included the reduction of air travel emissions in their strategy papers, and are willing to work on a more sustainable staff mobility. However, ecological necessities and the requirements of international university cooperation are often perceived as an unreconcilable dilemma. Challenges for researchers must be detected and solutions to be elaborated how university institutions cannot only theoretically address climate change, but also actively participate to limit climate change and its consequences. In the context of launching a new sustainability strategy, the Zurich University of Arts (ZHdK) aimed to identify promising interventions to encourage their employees to fly less, alternatively using a more environmentally friendly travel mode or switching to different means of communicating to their peers.

2. METHOD

In an online survey, 231 of the university's employees responded to hypothetical travel scenarios in which the impact of three randomly assigned interventions, their combinations, and a control condition were tested regarding travel decisions (plane or train) for a short (Zurich -Dusseldorf) and a medium trip (Zurich – London). The three tested interventions were: 1) information about emissions and usable travel time, comparing air and rail travel, 2) a service for the planning and booking of trips by train (only for the short-distance condition), 3) financial compensation for additional costs when choosing the train (only for the medium-distance condition). Additionally, for the medium distance trip participants were asked how their decision would differ if there was a night train with sleeping compartment as an alternative to the day trip. To gain information about supportive and impeding factors for ecological alternatives to flying, a number of other items was included in the online questionnaire, e.g. asking participants about their reasons not to choose video conferencing. Based on the available data, a multiple regression was conducted.

3. RESULTS AND DISCUSSION

Prerequirements concerning the data were met, cases with missing data were excluded from further analysis. Neither the given information nor the travel booking support showed significant influence on the participants' choice for the short-distance trip. For the medium-distance trip, though, participants who had seen the information and/or received financial compensation chose the train significantly more often than the control group, with the combination of both interventions being more effective than the information or the financial compensation alone. Most effective concerning the participant's choice to choose the train instead of the plane for the medium-distance trip, was the offer to make the train trip by night in a sleeping car. Reasons not to use video conferencing were the perceived necessity to be present in person, the joy of travelling, and, to a minor extent, infrastructural shortcomings (appropriate rooms, technical problems). Looking at the travel purposes as well as considering the open comments made by participants, the perceived necessity to be present in person seems to some degree be driven by social norms rather than technical impossibilities to replace actual presence with virtual presence. While these results hint towards possibilities for less air travel within medium distances, they also suggest that video conferencing is unlikely to lead to the reduction of large quantities of air travel emissions concerning long distances, which is consistent with the findings in other works of research (e. g. Beaverstock, Derudder, Faulconbridge, & Witlox, 2009). The question arises whether solutions can be found that address the employees' needs for personal international contacts and professional exchange, but do not result in frequently undertaken short and far trips.

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A MULTIDISCIPLINARY APPROACH TO ASSESS END-USERS' PREFERENCES AND QUANTIFY ELECTRICITY DEMAND FLEXIBILITY

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Keywords: Smart grids, Demand flexibility, End-users, Multidisciplinary

1. INTRODUCTION

End-users are expected to have a more proactive role in smart grids, contributing to balance demand and supply by making an integrated management of energy resources and participating in emerging markets.

Current literature on end-users' demand flexibility follows mostly an engineering and algorithmic based research to estimate the flexibility potential in the residential sector [1][2]. However, there is a growing line of research addressing these issues from a social perspective [3], exploring topics such as end-users' preferences regarding the adoption of dynamic electricity tariffs [4][5][6][7], acceptability and participation in demand response programs [8][9][10], and assessing end-users' flexibility [11][12] [13] [14]. Despite these advances, multidisciplinary approaches of demand-side flexibility are needed to make a holistic assessment of technical, economic, social and users' behavioural challenges in smart grids [6][11].

2. METHODOLOGY

This work combines expertise from engineering and social sciences to assess end-users' preferences and quantify electricity demand flexibility in a residential setting. A face-to-face survey was developed and implemented in a representative sample of a Portuguese neighbourhood to characterise households' flexibility. Interviews were carried out in around 400 households from February to March 2018. The survey assessed end-users' willingness to accept load management actions as well as to enrol in a dynamic tariff scheme, and characterised the households regarding electricity supply, equipment ownership and time-of-use, including electric vehicles, mobility patterns and sociodemographic variables. These results were used to validate an engineering bottom-up model of end-users' flexibility.

3. RESULTS AND DISCUSSION

Preliminary results indicate that the demand flexibility of this neighbourhood is limited by its characteristics concerning electricity consumption and equipment ownership. Moreover, although end-users give the impression to be open to accept load shedding, the behavioural flexibility associated with specific appliances is small. Respondents are also willing to accept direct load control if adequate financial counterparts are provided. However, results also show that when faced with the possibility of enrolling into a dynamic tariff scheme, end-users would not adopt time-differentiated pricing schemes because economic benefits did not compensate their percepetion of inconveniences.

4. FINAL CONSIDERATIONS

The transition to smarts grids is an on-going process that may both shape and be shaped by end-users' preferences and behavioural adaptations. Understanding and anticipating these issues, particularly by using approaches bridging engineering and social sciences, will contribute to the development of a more efficient and resilient power grid, which hopefully will be more adapted to end-users' expectations.

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THE EFFECT OF WORKING STATUS IN STRUCTURING PEAK ELECTRICITY DEMAND

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Keywords: flexibility**,** time use survey, sequences, work

1.INTRODUCTION

The proposed paper aims to analyse the effect of the paid working schedules on structuring the peak electricity demand. The starting point of this paper are the findings that suggest that employment increases the coordination and synchronicity of everyday activities among individuals [1]. This means that employment not only structures daily life but also effects the timing of electricity demand.

2. PRELIMINARY RESULTS

The proposed paper uses data from the UK Office of National Statistics Time Use Survey (TUS) of 2014/15, which provides detailed information about what individuals are doing and when during the course of 24 hours. Our dataset includes 4,248 employed individuals and 356 unemployed individuals, adding up 4,604 cases. In order to identify how employed and unemployed individuals differ in time use we examined the average time spent in the first 20 primary activities during peak times (4pm till 8pm) (Figure 1.).

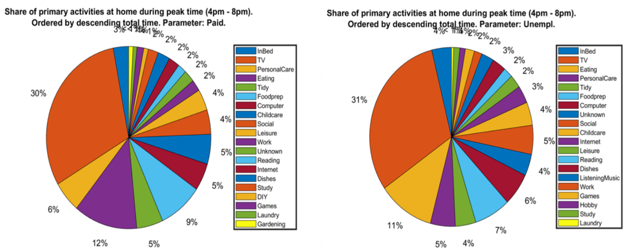

Figure 1. Share of primary activities at home during peak time (4pm-8pm) among employed and unemployed

Our preliminary findings suggest workers time is dominated by work related activities (such as laundering or food preparation activities) while in the case of unemployed people the most common activities are socializing, eating or child care. In our presentation we report the means or the average amount of time spent in the first 20 primary activities during peak times (4pm till 8pm) and the result of the independent t-test used to identify significant differences in time use between employed and unemployed individuals. The most frequent work schedules reported by individual's starts from 9am till 4.30pm. Thus, our preliminary findings suggests the time spent in paid work is centred on midday, with typical break for lunch. Independent sample t test was used in order to identify gender differences in the time spent in work.

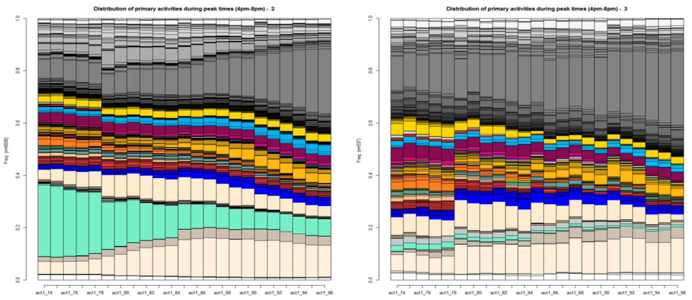

Figure 2. Distribution of primary activities during peak times (4pm-8pm). The distribution of employed people activities are indicated on the right diagram and unemployed people activities on the left.

Our preliminary findings suggests that synchronisation of employed people morning activities is higher than their evening activities. Furthermore we argue that employed people have an organized set of activity pathways between 9am till 4.30pm. The morning activity and evening sequences are dominated by sleeping activity. The main difference between the two groups is in the way activities are structured in time (Figure 2). Employed people activities sequences are bound around work activity. This is not the case of unemployed people as few activities serve as fixed activity for group members. The statistical tests will be reported during our presentations. Using Ward for clustering method we identified 4 different clusters of sequences that characterize employed and unemployed individuals based on their time usage. Finally, we present the result of our subsequence analysis of events that are strongly related with employment status. The discriminant power is evaluated with the p-value of a Chi-square independence test.

2.1. SEQUENCE-NETWORK ANALYSIS

There are different methods for measuring similarities and distances between sequences [2]. The method applied in this paper is the optimal matching from R package TraMineR. All analyses were performed with R.

3. PRACTICAL IMPLICATIONS

The results provide evidence that flexible working schedules diffuse peak electricity demand. Flexible working schedules change the nature (e.g. structure) of working activities and this can be applied in designing interventions aimed at reducing peak electricity demand.

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HUMAN-CENTRED SERVICE DESIGN WITH BIG DATA APPLICATIONS FOR SMART BUILDINGS

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KEYWORDS: service design, big data, human-centered, smart building

ABSTRACT

The smart building concept is constantly evolving. It is dynamical in its nature and various actors are inserting different components, functions and preferred outcomes into the concept to fit with their perception. At the same time, many existing definitions share central ideas of what a smart building is – interconnected, flexible, automated, energy efficient and comfortable for the occupants. As buildings are becoming increasingly complex they are generating vast quantities of data. A human-centered service design is defined as a bridge between the "what" and the "how" of a service [1], which mediates between customer needs and the strategic intent of a company [2]. The importance of designing new services has gradually increased because of various customer demands, competitive environment, and platform economic strategy trend. Human-centered services are commonly designed through intuitive, investigative, and analytic approaches [3]. In the intuitive approach, services are designed on the basis of the intuitions of service designers, which are gleaned from activities such as brainstorming, inclusive workshops and living lab sessions. The investigative approach designs new service concepts by asking for customers' ideas directly, for example, through active feedback loop with users. The analytic approach uses engineering methodologies and tools for designing new services through advance big data analitics. Several studies have explored the approaches to designing new services, including a computer-based tool to design the functions of a service concept [4], a morphological approach to designing new smart service concepts [5], and a knowledge-based method for designing product service system concepts [6]. Opresnik and Taisch [7] similarly noted that the utilization of data from customers can facilitate the development of services in manufacturing industries. Huang and Rust [8] indicated that service companies can leverage and transform customer data into useful information about customers for strategic marketing planning. For example, Sakao and Shimomura [9] proposed a computer-based tool to design the functions of a service concept for satisfying customer needs. The mentioned studies can support the design of new services using data. However, the applicability of the results is limited because these studies do not focus on the use of data to service design. In addition, human-centered services that can be deployed at scale requires adequate experimentation environments and real end-user involvement in which these services can be matured and their effectiveness understood before commercial roll-out. The present study focuses on service design starting from the users' needs and experience and associated data, which will be interconnected with different types of data, generated in the building internally and externally. The approach suggested in this work is aimed at providing a systematic procedure that links data analysis to human-centered service design.
This study proposes a data-driven approach to service design integrates insights from the data science, service design and behavioral science. The proposed approach aims to enhance the effectiveness and efficiency of new service design starting from the users' data. The proposed approach contributes to

the continuous design of new services for smart buildings by enabling efficient data analysis and further creating a synergetic effect when incorporated into existing approaches to service design. In order to create a dynamic experience that can be continually tuned and tweaked to benefit the consumer, data must be collected, analyzed and acted on from two source points: the customers and the contextual environment. Designs should be immersed in behavioral data from the concept stage. A challenging but critical aspect of this approach is establishing the capability to capture highly detailed behavioral and customer preference data, which entails the liberation of customer data from individual silos within an organization. Awareness and concern about data privacy and specifically the use of personal information by digital service providers and communications channels will be one of the most significant issues of the study. This research project contributes with increased knowledge on how an integrated approach that iteratively delivers the right data insights will not only improve the quality of life and convenience of citizens in indoor spaces, but also contribute towards more sustainable cities through more efficient utilization of scarce resources such as energy and water.

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SEGMENTATION AND CHARACTERIZATION OF CUSTOMERS USING ONLINE GAMES IN THE ENERGY SECTOR

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Keywords: Gamification, Energy usage, Energy efficiency, Behaviour, Customer Segmentation

1. INTRODUCTION

Switzerland has decided on an energy transition towards a more renewable energy production, thus reducing and eventually removing the share of nuclear power production in the Swiss energy mix. Furthermore, there is a great interest in reducing energy usage and shifting the energy demand to reflect more sustainable, decentralized, and non-dispatchable sources. Public acceptance and support in this process is crucial and different methods to achieve the long term behavioural changes have been examined [1],[2]. It has been shown that intrinsic motivation is one key factor that leads to long-term change and therefore some research has focused on the possibility to use gamification as a means to engage customers [3],[4]. Playing can allow for contextual real-life learning and self-evaluation, making feedback more constructive [5]. The use of gamification in typically non-game environments, like energy usage, might encourage participation in public issues and enhance problem solving.

While most research on gamification in the field of energy focuses on the effectiveness of such interventions, e.g. the framing and motivational setting, much less is known about the participants. What segments of the population can be reached via this approach? Are there segments that are more active who also read texts with background information? In this analysis we aim to address this gap, by investigating the participant segmentation of an online game created by a large Swiss utility.

2. GAME AND SURVEY

The Swiss energy market is planned to be fully liberalized in the near future. Therefore, many utilities have started to professionalize their customer relations. On the occasion of an anniversary, in autumn 2017, a utility launched a free game app for its customers over the age of 17. The research team followed up on the impact of the app with a survey and analysis.

2.1 The Game

The app consisted of six separate stages comprising simple, Tetris-like games, as well as more complicated augmented reality games, which required being outside in the city. Within each stage, information was also available about different electricity topics. Each week one of the six games was released, so the gaming period lasted about two months. Attractive prices were offered as incentive for the best players. The prizes ranged from 15000 CHF for the first prize, 4500 CHF for the second and 1000 CHF for the third prize in the different stages. The app had 4855 active users, i.e. individuals who downloaded the app and registered with their e-mail address. The ranks of the players with their login names were published in the app, visible for all participants. This data was saved with the emails, thus the overall ranks and game activity could be connected to the online survey responses.

2.2 The Survey and Analysis

After the game period was finished, the participants were invited to take part in a survey. 426 individuals participated (response rate = 9%). Questions addressed socio-demographic information, their overall impression of the app, how they liked the different stages, whether they read the provided background information, the player's attitude towards green electricity and consumption, how they perceived measures to save energy and if they learned something by using the app. This allowed us to test the hypothesis whether active players were more likely to learn from the game and have different socio demographic characteristics. For analysis the players were separated into four groups: intensive gamers (IG), medium-level gamers (MG), low-level gamers (LG) and non gamers (NG), according to their gaming behaviour (score achieved and time played); and further into three groups according to how they read the information ("Read", "Partly read", "Not Read"). With this categorisation, we were able to find out different characteristics of these user groups.

3. CONCLUSIONS

The participant segmentation of the game is analysed to test the proposed hypothesis. While it is clear that the augmented reality games attracted less participants, the ones that played these stages were very engaged in the whole app. The small group of IG (6%) is the youngest with an average age of 33, the other groups where much older (MG, 21% with average age of 35; LG, 62%, ave. age 42; and NG, 11%, ave. age 51). There were significantly more men playing the game, only 1/3 being women. The IG group not only spent a lot of time with the game, but also read almost all of the information. The LG and NG group read less information, although even in the NG group over 60% read at least part of the information. In terms of energy usage the groups did not answer about their self reported behaviour very differently, but here follow up research is needed. Overall there are differences – like age, education and reasons for playing between the user groups which might help to improve the use of such games to reach customers with information about energy topics. From the research, conclusions can be drawn how to adress the different user groups and who cannot be reached by such games.

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What deters small private landlords from making energy efficiency investments? A mixed method approach applied to a depressed neighbourhood in Germany

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Keywords: Energy renovation, landlords, decision-making, mixed method, case study

1. INTRODUCTION AND RESEARCH QUESTION

The building sector has a crucial role to play in achieving Germany´s climate protection targets because it causes one third of German GHG emissions [1, p. 5]. Germany aims to achieve a “virtually climate neutral building” stock by 2050 [1]. The German building sector has successfully reduced its CO_2 emissions by 43 % since 1990 [2], but in recent years this emissions reduction has tailed off. It is well-known that the approach to property renovation and energy efficiency improvements varies between different types of property owners. Properties owned by not-for-profit housing associations and, to some extent, owner-occupied homes experience higher renovation rates and energy efficiency performance than properties owned by private landlords [4].

To understand why there is lower investment in privately rented apartments, and what motivates landlords in general to invest in their properties, three main aspects of the public, political and scientific debate must be considered. Firstly, the investor-user dilemma, also known as split-incentive, which can prevent necessary energy renovations. To overcome this problem, Germany has introduced a number of specific policies, but these lead to the second aspect – the claim that these policies are misused, with the result that energy renovation leads to higher rents, higher returns and “energy gentrification”. Finally, in a prosperous rental market energy renovation processes are seen to be unnecessary for attracting tenants due to the high demand for living space.

The debate falls short in two areas. Firstly, the argument focuses on prosperous markets. Secondly, it neglects the heterogeneity of landlords, ranging from different types of commercial landlords to non-commercial small private landlords (SPL). This article addresses these research gaps and analyses the decision-making processes relating to energy efficiency investments in a depressed rental market in the city of Oberhausen to identify and understand the factors which motivate or deter SPL from making energy renovations.

2. DATA AND METHOD

The author used a sequential qualitative-quantitative mixed-method research design to understand the decision-making processes of SPL [5], [6]. In total, the author conducted 18 interviews (ranging from 37 to 115 minutes each) and analysed these using content analysis. The sampling was ‘purposeful’, aiming for maximum variation [8, p. 169ff]. Therefore, both renovators and non-renovators were selected.

Subsequently, a postal survey was conducted in spring 2017 using the “tailored-design method” [9]. The aim was to understand the significance of 15 determinants, identified in the qualitative research and based on a literature review, which relate to the decision-making processes of SPL. In total, 351 SPL participated in the survey (26 % response rate). The survey was analysed using a hierarchical regression model, with each determinant assigned to one of the four dimensions of decision-making as defined by Stern et al. (2000) [10]: (environmental) attitude, habits, individual capability and external factors.

The author conducted the qualitative and quantitative research activities in a small inner-city neighbourhood in Oberhausen. Oberhausen is a German city in the Ruhr area with approximately 212,000 inhabitants. The city and neighbourhood are closely linked to the rise of the coal and steel industries at the end of the 19th century and their decline from the 1960s onwards. Consequently, the case study represents neighbourhoods suffering from high vacancy rates, low rents, a high share of low-income households with a heterogeneous building ownership structure and buildings mainly constructed prior to, or during the early decades of, the 20th century. Such neighbourhoods exist in other parts of Germany, such as Saarland, Bremen, parts of former East Germany and other cities in the Ruhr area, as well as, in all likelihood, in other European neighbourhoods dealing with economic structural change.

3. RESULTS AND DISCUSSION

The analysis provides insights into the decision-making processes of a neglected actor in the German Energiewende: small private landlords (SPL). Although SPL own 37% of all apartments in Germany, little is known about their decision-making processes in relation to energy renovation investment. The analysis underlines the complexity of the decision-making process, because each of the four decision dimensions contributes to the understanding of investment decisions. This means that attitudinal (personal norms) and habitual (identification with the property and the neighbourhood) determinants, as well as aspects of individual capability (knowledge, personal networks) and external conditions (rental levels) are relevant for understanding the investment decisions of SPL.

The analysis may differ under different rental market conditions; however, it shows that the decision-making process is complex and, consequently, comprehensive understanding is required in order to design appropriate policies to maximise existing energy efficiency potential. In particular, it is clear that the existing policies, which focus primarily on deep renovation and financial incentives, are inadequate for addressing the needs of SPL.

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DECISION-MAKING IN BUILDING RETROFITTING: LESSONS FROM DYNAMIC MODELLING OF SCENARIOS FOR GOTHENGURG CITY

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Keywords: Decision making, Energy efficient renovations, Dynamic modelling, Multifamily buildings, Gothenburg

EXTENDED ABTRACT

High energy-renovations rates and deployment of decentralized renewable energy sources are identified in global assessments as key for the buildings sector contribution to achieving ambitious climate targets. The implementation of this sustainable transformation is however not straight forward for regional and city governments as well as urban stakeholders including property managers. In fact, although this implementation is often assumed to be driven by cost-efficiency as life cycle cost has long been used to communicate the value of investments in energy efficiency [1], it is well known that decisions on profitable investments are typically delayed [2].

To foster the widespread adoption of efficiency measures in buildings, a series of works focus on leveraging information to support the decision-making, for instance via Decision Support Systems [3] or visualization [4]. Another line of work tries to support policy development by understanding agents' behaviour. Behavioural approaches in the literature include a disaggregation of the agents' decisions, represented by varying requirements on risk (discount rates are available [5, 6] even distinguishing different rates of impatience for different attributes [7] and including housing market capitalization [8]) and return of the investment varying for different decision makers [9], as well as corrections of the cost-efficiency by increasing the energy costs with rebound effects [10] or with stochastic modelling where the updated energy saving benefits follow a geometric Brownian motion [11]. An alternative possibility is to assign market heterogeneity the different retrofitting options [9,12,13,14]. Probably due to computational feasibility, the works above can only address a typological description of the stock to be renovated or a limited number of buildings or case-studies, unlike many current urban models that can assess all existing buildings.

We present a bottom-up dynamic modelling framework that incorporates some of the reality of the decision-making processes when implementing building renovations to a detailed characterization of building stock, taking as a case study all multifamily buildings in Gothenburg city (Sweden). The modelling is based on real conditions of existing buildings – retrieved digitally from the national Energy Performance Certificate database, building and property registers, and cadastral

maps from the city planning office – [15] and, although it is explorative, accounts for reaction capacity in terms of i) investments for all property owners and ii) total workmanship capacity in the city. We consider one scenario driven by cost-efficiency and one by technical renovation needs (end of lifetime of building components), both including different levels of reaction capacity. The modelling framework is easily replicable to other regions and cities [16]. The retrofitting includes, as individual measures as well as in packages, increased insulation level, increased efficiency of lighting and appliances, installation of heat recovery systems and photovoltaic panels.

Whereas continuous implementation of energy efficiency actions simultaneously to the technical renovation needs could lead to very low energy demand and even to the buildings being energy producers by year 2050, an implementation strictly driven by cost-efficiency (from the property-owners perspective) would only reduce the energy demand by 5% during this time period and would not fully utilize the investment capacity. Furthermore, the current limitations of reaction capacity – for the market shares assumed – can only reduce demand by 15% during the same period. Workmanship capacity appears as more constraining than investment capacity: it is identified as a local imperative need and also suggests co-benefits related to job creation within the construction sector.

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BEHAVIOURAL CHANGE INTERVENTIONS TO REDUCE ENERGY USE FOR LIGHTING IN PRESCHOOLS: A PILOT STUDY

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Keywords: Behavioural change, Energy saving, Intervention, Light, Preschool children

1. INTRODUCTION

Environmental education in early childhood has been highlighted as having a potential to promote energy saving behaviour from an early age [1]. Among educational tools, games, board games [2] as well as visual items [3] have been suggested as common and useful formats to convey information on a specific topic and also, promote behavioural change. Taking the social cognitive theory [4] as a point of departure, games may promote learning about energy saving behaviour and visual prompts may further enhance awareness and actual behaviour at a place [3, 5]. This paper presents a pilot study of interventions promoting behaviour change among 3-6 year-old children. In particular, we studied one of the simplest energy saving behaviours which is turning lights off when leaving an empty room. The main objective was to determine whether games and visual prompts can be used to make the children aware of turning lights off and thereby, promoting this behaviour in preschools.

2. METHOD AND MATERIALS

After obtaining an ethical approval, the study took place in two departments at a municipal preschool in Southern Sweden. A total of 27 children participated in the study. A digital game (intended for 1-2 players playing with a tablet) and a paper-board game (intended for 2-4 players) were developed in parallel with the main principle that players have to turn lights off in empty rooms in a preschool. A visual prompt consisted of two signs showing the pictures of a light-on and light-off lamp  respectively, with a size of 6.5 x 6.5 cm.

An initial observation was conducted for 3 days from 9:00 to 15:30 under 2 weeks to provide baseline data. A researcher observed whether the children turned lights off when leaving empty rooms. Besides, energy meters measured lighting energy use in two toilets where the children have individual control over electric lighting in their respective departments. The games were then introduced (the digital board game was introduced to 10 children in the first department and the paper-board game was introduced to 17 children in another department); the children could also play game later as part of the daily indoor activities. Thereafter, visual prompts were introduced and placed adjacent to light switches. The children were asked a few questions in relation to the games and prompts. The observations and energy measurements were conducted about a week after the interventions of games and visual prompts, respectively.

3. RESULTS

When the children were asked about what they did in the games, about one-third answered "turning lights off" and further, they could answer "when leaving". The children were also asked about the ability and how to control lighting in their respective departments. The majority answered and/or showed that they can turn lights on/off. After the game interventions, occasions that the lights were turned off in empty rooms were found to increase by about 6% for the children playing the digital game and 28% for the children playing the paper-board game. When introducing the two signs the children were asked what they saw and about half of them answered "lights on" and "lights off and/or turning lights off", respectively. After the visual prompts were placed, the light-off occasions were found to increase by 23.60% for the children who played the digital game whereas there was an increase of only 1% for the children who played the paper-board game. Chi-squared tests showed associations between the interventions and the behaviour (X^2 (2, n = 147) = 11.49, p < 0.005 (2 sided), Cramer's V = 0.28 for the department with the digital game, and X^2 (2, n = 126) = 13.59, p < 0.005 (2 sided), Cramer's V = 0.33 for the one with the paper-board game).

Energy used for lighting in each of the toilets decreased by about 40-42% after the game interventions. For the department with the digital game, the energy use increased slightly after the prompts were placed; but the amount was still less than the baseline data. For another department with the paper-board game, the energy use was found to be more than the amount measured after the game intervention and also, the baseline data.

4. DISCUSSION AND CONCLUSIONS

The pilot study showed that the games and visual prompts could convey information about energy saving behaviour among preschool children and also, influence the actual behaviour. The observed behaviour was found to be in line with actual energy used for lighting in the toilets to some degree. The results obtained from the two children groups, however, were not very consistent. Also, effects of the digital game and visual prompts can still be questioned in comparison to the paper-board game. Though the majority of the children could perform the behaviour i.e. turning lights off, it was often observed that they did not do so. There may be other possible factors that could influence, such as norms and habits. These factors should also be considered for design improvements of the interventions.

It is noted that the ability to generalise the results could somewhat be limited because of our small sample size. The pilot study mainly aimed to determine whether interventions using the games and visual prompts could influence the behaviour and thus, the observations and measurements began within a short period of time after the interventions. Regarding this, the extent to which the interventions can effectively be used to promote the behaviour should further be examined.

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Methaporical Visualizations of Energy Saving Impact for Behavioural Change: A Goal-Framing Approach and Results from an Online Crowd Evaluation

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Keywords: Energy consumption visualizations, metaphors, persuasive systems, crowdsourcing.

1. INTRODUCTION

One of the most common technology-enabled strategies for stimulating behavioural change for energy saving has been the provision of feedback on one's energy consumption. However, the design and effectiveness of consumption visualizations is not yet well understood, as can be seen from substantial differences in approaches and their impact on consumption [1]. While it is often assumed that providing feedback will automatically lead to a change in behaviour, effective visualization models need to consider differences between users, in terms of their environmental goals and values [2], and their needs with regard to consumption feedback [3]. The design of data-oriented visualizations has been most frequently explored (e.g. bar or pie charts), but there is a large class of users with a low data affinity who cannot easily understand abstract numerical energy consumption information [4]. Alternative approaches include the use of metaphors that visualize the impact of consumption by showing information of (eco-related) phenomena known from everyday life [1][5]. This paper describes the theoretically-grounded design and evaluation of metaphor-based visualizations of energy consumption impact within the EU-funded enCOMPASS project (Grant Agreement no. 723059.), providing initial evidence for the persuasive potential of the designed solutions.

2. APPROACH AND VISUALIZATION DESIGN

To address the described differences in user needs, a metaphoric visualization of consumption impact for stimulating energy saving has been developed. It is part of a mobile app that also includes a range of gamified incentives, and personalized recommendations for energy saving. In this paper, the metaphoric impact visualization is addressed. Departing from Goal Framing Theory [2] and users' motivations for using energy feedback systems [3], three main goals for using energy saving applications are distinguished: normative goals (e.g. protecting the environment), gain goals (e.g. saving money), and hedonic goals (e.g. enjoying saving energy). The impact visualization consists of three views that relate to each of these goals. The view relating to the user's most important energy saving motivation is displayed by default (based on data obtained from a sign-up form), but users can switch between views at any time. Each view depicts the energy savings obtained from the start of using the app to the current month. The *'save money' view* displays the amount of money saved on the electricity bill, visualized through the corresponding number of piggybanks filled with coins. The *'save the environment'* view displays the total amount of CO_2 that was not emitted as a result of the savings, visualized through the corresponding number of trees (where the number of kg's of CO_2 saved reflects a "typical" absorption capacity of a tree over a year's time). Until the capacity of a tree is reached, CO_2 clouds fill up the tree before a new tree is added. The *'enjoy saving energy'* view relates to the gamified achievements of the user. It depicts jars filled with candies corresponding to the points received for the achieved savings, including progress towards the next reachable badge. In each view, users can also move back and forth between the months to compare their progress.

3. FIRST EVALUATION IN AN ONLINE USER TEST

As a first assessment of the described visualization model the impact visualizations have been evaluated with European crowd workers on Amazon Mechanical Turk using two crowd tests. Thirty-three people completed the test for the monetary and the environmental, and 32 people for the hedonic visualization. In the beginning of the test for each visualization participants answered questions measuring their overall goal-related values with items from [6]. The evaluation focused on comprehension, pragmatic and hedonic quality [7], and perceived impact on the participant's motivation for energy saving. For each impact visualization the participants were presented with screenshots and associated evaluation questions. To illustrate the dynamics of the visualizations, we utilized animated gifs showing different consumption scenarios and provided instructions to the users to imagine themselves using this application in a specific context. The results have shown a high understandability of the applied metaphors for the monetary and environmental visualizations (73% fully or partially correct answers), with somewhat lower values for the hedonic visualization (56%). The relative amount of savings achieved was well understood in all three cases (85%, 73% and 78% correct answers, respectively). With respect to their overall hedonic and pragmatic qualities all three visualizations received similarly positive ratings, with some differences on the individual items (e.g. the monetary and hedonic views were perceived as somewhat easier to understand, while the environmental one was perceived somewhat more beautiful than the others). Most importantly, the measured perceived motivational effect of all three visualizations was relatively high (82%, 88% and 84% strongly or slightly agreeing, respectively). Furthermore, correlational analyses suggest that environmental and egoistic (e.g. wealth) values affect the impact of the different visualizations on the user's motivation to save energy. Finally, answers to open-ended questions revealed suggestions for improvement of individual aspects of the specific visualization designs.

4. CONCLUSIONS AND FURTHER WORK

Overall, the results suggest that the developed model for metaphorical visualization of the impact of energy savings was well-understood, motivating and liked by the users. In particular, the results suggest that grounding the visualizations in goal-framing theory is a promising way for designing persuasive, easy-to-understand energy consumption visualizations that target the awareness of energy consumption impact through metaphors from everyday life. The developed visualizations are currently being implemented as part of the enCOMPASS mobile app, which will be longitudinally evaluated in real-world pilots in three different European countries.

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DIGITAL SUFFICIENCY: AN INTERDISCIPLINARY APPROACH TO PROMOTE ECO-SUFFICIENT USE OF DIGITAL MEDIA

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Keywords: energy sufficiency, digitisation, behavioural change, adolescents, social marketing

1. INTRODUCTION

In the era of digitisation, smartphones have become a necessity in adolescents' lives. In Switzerland, the smartphone penetration among adolescents is almost 100 % [1], and adolescents replace their smartphone every two years [2]. Also, new forms of mobile communication besides phoning emerged (i.e., text-, picture- and video-based), resulting in increasing data traffic in the mobile phone networks. Thus, the current consumption patterns of adolescents might increasingly affect the environment, since during a smartphone's life cycle, natural resources are depleted, and energy is consumed. Besides certain advantages for the environment [3], a few studies have demonstrated that the use of digital devices has an increasing impact on energy consumption and related environmental impacts [4]. Current solutions in Europe for reducing energy and resource consumption from ICT mainly focus on structural interventions, but often do not consider the individual behaviour. It is the goal of the present research project to decrease the overall impact of digital media use on energy and resource consumption among Swiss adolescents. In the presentation, we will describe an interdisciplinary intervention developing process, and we will exemplify based on the topic of digital sufficiency how social and natural scientific approaches can contribute to develop a behavioural change campaign fostering sufficiency.

2. PROCEDURE

To develop the sufficiency campaign, we conducted five phases: 1. A representative standardized media usage survey of German-speaking Swiss adolescents and young adults assessing media usage frequency (n = 833, age 12-25); 2. Identification of media use patterns for smartphone plus additional digital devices (e.g., tablet, laptop); 3. Modelling the ecological impact of the media use patterns via life cycle assessment (Ecological Scarcity Method, cf. [5]); 4. Development and implementation of the campaign based on a social marketing approach (e.g., [6]); 5. Evaluating the campaign's effectiveness. We adopted an interdisciplinary procedure, because, first, bottom-up data about the ecological impact of individual media use were not available. Second, to guarantee the campaign's ecological relevance, the combination of survey data and LCA allowed for identifying the adolescents' behaviours that have the highest ecological impact. Third, to increase the campaign's effectiveness, the campaign's contents should be tailored to the target group's knowledge and behaviours. Phases 1-3 have been already completed; phases 4-5 will have been completed by September 2018.

3. SELECTED RESULTS

3.1. Digital media use patterns and level of environmental awareness

The survey's overall target was to assess the digital devices and activities with which the adolescents spent the most time. Among the sampled devices, the smartphone was used most often with an average duration of 189 minutes a day. The most frequent activities were using messenger (e.g., WhatsApp) and social network services (e.g., Facebook) and watching videos (e.g., Youtube). In general, the most frequent activities differed between the sampled digital devices and three user clusters.

3.2. Environmental impact of digital media use

The total ecological impact according to the Ecological Scarcity Method of an adolescent's digital media use per day is 1'100 ecopoints, which is comparable to the impact of driving 3.2 km by car or eating one beef hamburger. Comparing the impact of the devices' life cycle stages, we found that the raw materials and manufacturing chain has a much larger share than the use phase, with ¾ of the total ecological impact. The larger the digital devices' size, the higher was their ecological impact. Specific activities such as sending text messages or surfing on Facebook were negligible.

4. CONCLUSIONS AND IMPLICATIONS FOR EFFECTIVE CAMPAIGNING

Based on the survey and the LCA, we draw the following conclusions for the sufficiency campaign:

- In terms of ecological relevance, changing adolescents' behaviours, which extend a device's lifespan and reduce the number of devices an adolescent owns, are more relevant than lowering the specific usage activities such as texting or surfing.
- Specific target behaviours in the scope of the sufficiency campaign can be: protecting the smartphone to extend its life, do-it-yourself repairing (e.g., broken screen), sharing devices with friends and family. To specify the target behaviours suited for the campaign we will conduct focus group interviews with the target group.
- In the campaign, we will focus on smartphones because almost every adolescent has his own smartphone and can control its use.

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INVOLUNTARY REBOUND IN LOW ENERGY BUILDINGS

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Keywords: Involuntary rebound, Low energy buildings, Thermal comfort, Preference variation

1. INTRODUCTION

German standards for energy efficient buildings demand increasing levels of insulation. However, it has been observed that the energy savings achieved are often lower than projected – an effect known as “energy performance gap” (EPG) [1]). The literature attributes this in large part to occupant behaviour. However, occupant behaviour is still not well understood [2]. We address this research gap by analysing the interaction of building characteristics and household behaviour in a case study of low energy buildings. We too observe an EPG, but we conjecture that it is to a larger part an “involuntary rebound”, meaning that the interaction between households and building technology changes in ways unforeseen by the planners and not intended by the households themselves.

2. DATA AND METHODS

We approach this topic mainly from the perspective of sociological practice theory [3]. Within an interdisciplinary team of social scientists and engineers, we study six buildings with eight apartments each, built in 2010 according to German EnEV 2009 standards. The thermodynamic properties of the buildings are described in a detailed report. During the winter months of 2017/18, we conducted 18 qualitative interviews with the residents, focusing on their energy consumption and the respective thermal and ventilation comfort. Data on the energy consumption of the apartments are recorded over the last eight years. Thus, our material comprises building physics and technical installation descriptions, energy consumption data, temperature measurements and window opening times, as well as interview data on the households' habits and evaluations.

3. INVOLUNTARY REBOUND

The conventional assumption of the rebound effect is that consumption increases in reaction to savings achieved through more efficient technology. For example, occupants voluntarily choose a higher room temperature due to more effective insulation and hence lower heating costs. However, the rebound we conceive is partly to be seen as “involuntary”, due to the following observations:

- Unexpected energy consumption mainly occurs during fall and spring months.
- Measured room temperatures even in winter times sometimes reach a maximum of 32°C, well beyond the usual thermal comfort limits [4].

- Reported as well as measured average temperature settings differ between adjacent apartments, ranging from 18° to 25°C. Differences in energy consumption between apartments are even higher.
- Interview partners report different thermal comfort expectations during the day, depending on different practices (watching TV, physical activity, sleeping).
- Interview partners partly report extensive ventilation practices.

Based on these observations, we presume that the involuntary rebound has three independent and combinable causes: 1) Negligence – occupants do not register open windows any more due to reduced draught and the resulting loss of biofeedback [5]. As a consequence occupants might forget to close windows when outside temperatures become cooler. 2) Heat transfer between adjacent apartments may not only result in unfair energy bills [6], but even in overall energy leakage – occupants who prefer a colder indoor climate may ventilate their apartments to get rid of undesired heat transfers from their neighbours. These heat transfers occur when the outside walls produce only weak cooling in relation to the heating inputs from neighbours. This is particularly the case with highly effective insulation of outside walls and when the gradient between inside and outside temperatures is lower (fall, spring, during the afternoon). 3) Asymmetric inertia: Temperature preferences vary during the day and may change rather suddenly. Because room temperatures can be reduced much faster by opening windows than by regulating radiators, occupants may choose to constantly keep thermostat settings at the upper preference limit and to lower temperatures by ventilating.
A detailed analysis of hourly data (currently underway) may help to differentiate between the causes.

4. CONCLUSIONS

If negligence and variant temperature preferences are the causes for involuntary rebound, two sorts of remedies are in reach to reduce the resulting EGP: Against human negligence, artificial intelligence may help to regulate heating valves and window openings in a more efficient way [7]. In the case of varying temperature preferences of occupants, the usually inert modern heating systems could be set to provide only a minimal temperature level, e.g. 18°C. Temperatures above this level could be reached with spatially more differentiating and temporarily faster reacting devices [8].

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ENABLING CHANGE? A NEW APPROACH TO ICT-BASED BEHAVIOUR CHANGE

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Keywords: Behaviour change, Energy savings, methodological approach, ICT-based interventions

1. INTRODUCTION: ENERGY BEHAVIOUR AND THE ENABLING CHANGE FRAMEWORK

Energy related behaviour change is starting to appear more frequently at the forefront of policy agendas and research funding calls as a prime focus for reducing energy consumption and improving efficiency across all energy intensive sectors. In recent years, numerous behaviour change programs and interventions have been designed to alter user behaviour. Some of the various methods used to change energy related behaviours have ranged from feedback, energy conservation campaigns, incentives, changes to policy and ICT. Information and Communications Technology (ICT) can be used for monitoring building performance including the energy consumption, the quality of the indoor environment and even user activity [1]. The versatility and opportunities of ICT in format (standalone devices or web platforms) and in functionality (apps and gamification), has made them instrumental for encouraging behaviour change, given the capability of collecting and translating energy use in order to raise energy awareness and encourage energy saving behaviours. However, the effectiveness of previous energy related behaviour change interventions has been limited due to poorly designed interventions that suffer from a lack of participatory engagement with all building users and weak evaluation methods to determine the intervention success [2]. This is often further complicated when behaviour change projects implement multiple interventions at the same time and therefore cannot separate out the impact of individual interventions.

Behaviours do not occur in isolation, but rather part of a wider system [3] e.g., energy use in a building is a system that includes the infrastructure, thermal comfort expectations, norms of behaviour, and much more. Therefore, a whole-system perspective, going beyond individuals' behaviour is key to identifying opportunities for significant and durable behaviour change. Whole-system perspectives form a large part of research-informed practice methods [4, 5]. One such method is Robinson's Enabling Change approach [5], which requires synthesising research evidence into an accessible format that is targeted towards developing effective behavioural interventions. The Enabling Change process consists of programme level and project level planning steps (Figure 1). These define the medium/long term objectives for the behaviour change intervention as well as the logistics of carrying out such interventions on the ground.

This paper introduces this novel framework and reflects on its application within an EU funded ICT Behaviour Change programme, highlighting some of the real-world issues and constraints, as well as opportunities, related to implementing an evidence-based behavioural change framework in practice.

2. RESEARCH APPROACH

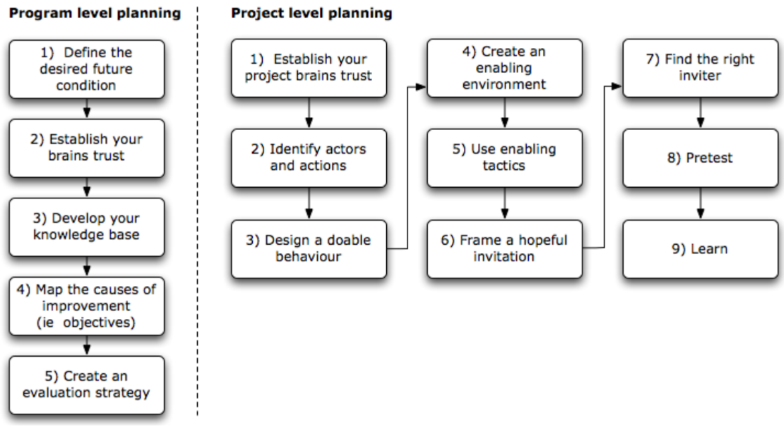

Figure 1: Enabling Change Process separated into different planning levels

eTEACHER, **e**nd-users **T**ools to **E**mpower and raise **A**wareness of behavioural **CH**ange towards **E**ne**R**gy efficiency, is a H2020 funded project (GA 768738) consisting of a consortium of twelve partners representing a range of expertise, across six different countries. eTEACHER aims to empower energy end-users to achieve energy savings and improve the health conditions and comfort in buildings by enabling behaviour change via a set of ICT solutions (Building Automation Control Systems 'BACS' add-on services and user friendly solutions such as apps and dashboards). This paper presents the methodological approach taken to design ICT-based interventions for successful behaviour change in each case study building.

A total of 12 buildings are being used as eTEACHER pilot buildings, including residential apartment blocks (n=5), schools (n=3), health care centres (n=2) and office buildings (n=2). The pilot buildings are located across three European countries: UK (n=2), Spain (n=6) and Romania (n=4). One of the biggest challenges for eTEACHER is that the case study buildings are all different; in use, type, location and ultimately the users of each building (residents, visitors, staff, students, patients, building managers and estate workers). Hence, an evidence-based framework is beneficial to the design of an effective behaviour change intervention, as this allows for consideration of the building specific energy-related behavioural factors and potential barriers in the design process. The Enabling Change framework has been applied to each pilot building to aid data collection and analysis in relation to designing and implementing an effective energy-related behaviour change ICT intervention. Feedback on use of the framework was collected from project partners at multiple opportunities including; project meetings, online workshops and 1-1 partner meetings as well as building users through the formation of feedback forums.

3. CONCLUSIONS

Analysis for this project is current underway and findings will be prepared and ready for September 2018. Our critique of applying the Enabling Change framework utilises eTEACHER project partner feedback, researcher reflections and evidence of issues and constraints that have arisen from applying the framework.

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HOW CITIES AND RESEARCHERS CAN SUCCESSFULLY COLLABORATE IN PLANNING, IMPLEMENTING AND EVALUATING BEHAVIOURAL-CHANGE INTERVENTIONS IN ENERGY

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Keywords: behaviour change, energy-saving interventions, evaluation, science practice collaboration

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1. INTRODUCTION

Cities take a key role in the energy transition. Many of them perform energy-saving interventions to engage citizens to change their behaviour. When conducting such interventions, collaboration between cities with academic partners is a promising and mutually beneficial approach. First such collaboration is important for designing effective interventions by taking into account both scientific and practical know-how. Second collaboration is important for systematically evaluating interventions to identify and multiply most effective approaches. Yet, such systematic approaches for science-practice collaboration in designing and evaluating interventions are rather scarce.
In an ongoing project, researchers from ZHAW and ETHZ have collaborated with three cities to systematically plan, implement and evaluate behavioural-change interventions. The aim of this presentation is to first give an overview of these interventions focusing on collaborative aspects. Second, we share insights from a workshop conducted with researchers and city representatives. The workshop focused on enabling factors for successful collaboration for designing behavioural-change interventions.

2. THREE INTERVENTIONS, THREE TYPES OF COLLABORATION

Researchers and practitioners were differently involved in design and evaluation of the interventions covering three types of collaboration: accompanying research, field study, co-design:
Accompanying research: The first intervention promoted the use of e-bikes instead of cars by means of a free e-bike trial. Practitioners took an active role in designing the intervention while researchers provided detailed evaluation. Our evaluation revealed the intervention's long-term impact on participants' car-related habitual associations (N = 400).
Field study: The second intervention promoted energy-efficient showerheads. Researchers took an active role in the design and the city provided a testbed: The intervention enabled visitors of a public swimming pool to try out low-flow showerheads. Our evaluation showed that such direct experience is relevant for the formation of attitudes about showerheads and for purchase decision (N = 400).
Co-Design: The third intervention promoted going to sports training by bike instead of by car among sports teams and individual sportspeople. Here, researchers and practitioners collaborated closely in design and evaluation of the intervention. The evaluation revealed that addressing sports clubs is a promising strategy to achieve behavioural changes and to reach target groups that are not yet environmentally aware (N = 220) .

3. WORKSHOP AMONG CITY REPRESENTATIVES AND RESEARCHERS

To collect further examples of collaboration and reflect respective experiences we conducted a workshop in the German-speaking part of Switzerland (N = 12 participants). Five city representatives and seven researchers collected enabling factors for successful collaboration in planning, implementing and evaluating interventions. Enabling factors were structured along three dimensions: i) individuals and teams (e.g., long-term commitment, importance of trusted personal relationships), ii) institutions and context (e.g., collaboration of city with local university, funding for evaluating interventions), iii) design of collaboration (e.g., space for reflexion and exchange in meetings). Furthermore, different barriers to successful collaboration have been identified and participants developed solutions to foster collaboration among cities and researchers for designing and evaluating interventions. A second workshop (planned for June 2018) will add respective experiences from the French-speaking part of Switzerland.

4. CONCLUSIONS

Experiences from the interventions and the workshop provide a solid basis to better understanding benefits of and barriers to science-practice collaboration in designing and evaluation behaviour-change interventions. Cities benefit from scientific know-how as well as systematic evaluation and researchers benefit from the opportunity to collect data in the field. At the same time institutional factors and funding schemes are crucial to realize collaboration. We will reflect and discuss ideas how such collaboration could be fostered.

6. ACKNOWLEDGMENTS

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SUSTAINABLE GRASSROOTS INNOVATIONS AS OPPORTUNITIES TO FOSTER SUFFICIENT LIFESTYLES

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Keywords: grassroots-based initiatives, social innovations, consumer behaviour, sufficiency

1. INTRODUCTION

Meeting the goals of the Paris climate agreement to combat climate change produced by CO_2 emissions will require fundamental innovations of how energy is produced and consumed on a systemic level. Eco-efficiency strategies will not do this job alone. Advocates of sufficiency strategies argue that we additionally need to reduce our energy consumption by simply consuming less. The sufficiency strategy demands people to change the way they live. Such changes in lifestyles are facilitated by reshaping the physical and societal (consumption) structures in a way that makes more sufficient behaviour more salient, attractive, convenient, and easier. One way of how such rearrangements of the external behaviour structures may evolve is the emergence and diffusion of social innovations and grassroots-based initiatives. Our research project aims to shed light on the potential and intermediary role of such grassroots-based initiatives in regard to the promotion of sufficient lifestyles. We are interested in what relevant attributes of different types of grassroots-based initiatives may be in order to address different antecedents of individual behaviour change, and thus in how initiatives can be characterized that are successful in fostering more sufficient lifestyles.

2. THEORETICAL BACKGROUND

In order to better understand the nexus between individual behaviour and external structures we rely our research on two research threads: First, we draw on research on social innovations, particularly on the work of Jaeger-Erben and colleagues [1], who distinguish different types of social innovations in regard with sustainable consumption practices, based on so-called consumption principles: Following the authors, innovation types differ in the degree to which they mainly provide new opportunities for alternative products, services and practices (need and utility oriented consumption), focus on enhancing new competences (competence-expanding consumption), or on bringing like-minded people together (collaborative consumption and community-empowering consumption).
Second, we rely on environmental psychological behaviour change theories, particularly on the comprehensive model of Klöckner [2]. This model integrates the most common behaviour change theories, namely, the theory of planned behaviour [3], the norm-activation-theory [4], the value-belief-norm-theory [5], and habits [6]. While this comprehensive model is particularly suited to explain private consumption decisions, for our context, it is equally important to understand, why individuals

engage in collective actions, i.e. why they initiate and join activities of grassroots-based initiatives. Research on collective sustainable behaviour has emphasized the role of social identity and collective efficacy beliefs as important drivers for participation [7].
To better understand whether and how grassroots-based initiatives might foster sufficient lifestyles we build thus a nexus of the typology of sustainable social innovations [1], and the antecedents of environmentally significant behaviour change [2], and collective action [7]. We assume that grassroots-based initiatives (a) provide "enabling structures", i.e. new opportunities for action by changing their accessibility and simplicity, (b) provide "motivational elements" that address individuals values, personal norms and self-identity (c) enable and create interactions within a group of like-minded people by "community-building elements" thus addressing perceived social norms, social identities and collective efficacy beliefs, and (d) provide new capabilities and skills by "competence-enhancing elements" thus enhancing perceived behavioural control.

3. METHOD

Our empirical work follows a two-step procedure. First, by means of 27 qualitative interviews with incorporators, users, and supporters of grassroots-based initiatives we explored, based on our theoretical assumptions, individual and structural factors that support or hinder the initiation, diffusion, and usage of such initiatives. Researched examples encompass various innovation types in the fields of mobility, food, and everyday consumption (namely cargo e-bike sharing, repair cafés, community-supported agricultures, and sharing platforms).
Second, we test for the relevance and exploratory power of potentially relevant attributes of the grassroots-based initiatives on psychological antecedents of behaviour change. To this we run a standardized online survey among users of the different grassroot-based initiatives (envisaged N = 200). By means of a factorial survey design [8], we experimentally vary the attributes of fictive initiatives presented. Multiple linear regression analysis will be calculated for analysing the data.

4. EXPECTED RESULTS

At the moment data gathering of the online survey is running. At BEHAVE 2018 we will present insights of our qualitative and quantitative empirical work, and derive implications for further research, as well as policy recommendations.

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MIDDLE CLASS CARBON CONSUMPTION IN MIDDLE INCOME COUNTRIES: CONCEPTUALISING CONSUMER BEHAVIOUR

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1. INTRODUCTION

Given climate change and growing middle classes, understanding consumer motivation and carbon consumption trends in middle income countries is vital for future sustainable consumption research and practice. Many international firms have already begun to target market segmentation in middle income countries, anticipating future trends. Sustainable consumption research has been rather slow in the analysis of the new middle class consumers in countries such as Ghana or the Philippines. This paper develops an innovative, interdisciplinary concept of middle class consumer behaviour in middle income countries. Drawing on insights from economics, psychology and political science, the paper identifies the key drivers of decision-making for the most emission-intensive goods and services at household level, ie energy consumption in the home/appliance use and transport.

Energy consumption tends to increase as households have more disposable income. The transformation of the poor into consuming middle classes is likely to have a large impact on energy and carbon consumption, also for the lower middle classes or “strugglers” (Birdsall 2015) on the brink of falling back into poverty. Discretionary spending may start at lower levels in middle income countries than in high income countries (Scholz/Guarin 2015). The acquisitions of popular goods such as a TV or air conditioner, a motorcycle or later a car changes the energy consumption and hence, the carbon footprint, of households moving out of poverty rather quickly. While the overall share of energy consumed by middle class households at this point does not match the energy consumed by industry, population growth and development dynamics will increase the share substantially in the years to come. Understanding the motivations of carbon-related decision-making and the resulting usage patterns is therefore an important step for both research and practice seeking to identify opportunities to foster sustainable consumption.

This paper develops an onion-shaped heuristic model based on economic theory (Bagwell/Bernheim 1996, Leach 1992) and the interdisciplinary energy consumption literature (eg Allcott 2011; Kollmus/Agyeman 2002). The most relevant drivers of decision-making among the new middle classes are proposed to be the following: internal factors central to the individual’s identity (income, attitude functions, aspirations) are at the core; social norms and status present the mid-layer of the onion; and external factors shaping the decision space (technology availability, infrastructure, policies) constitute the outer layer.

An individual’s identity is shaped by more than the factors mentioned. However, this paper argues that the core of the “carbon consumption onion” is made up of the four factors mentioned that are likely to explain a large part of energy- and transport-related behaviour. Attitude functions of the individual towards specific environmental challenges such as congestion or air pollution in the direct vicinity of the home are likely to influence decisions more than abstract challenges such as climate change. The level of income or actual spending capacity is an economic factor that constrains decision-making, especially if it comes to the size of the family network that needs to be supported. Here, the effect of remittances (both financial and social) is particularly relevant in countries such as Ghana and the Philippines, where the share of remittances in household income is high. The aspirations of the

individual) may lead to decisions that override spending capacity considerations, for instance if a new car or a bigger TV is bought.
The mid-layer of the onion sets the consumer in his/her social surrounding. Conspiciuous consumption driven by status considerations has been part of economic and sociological research for decades, but it is not clear yet to what extent it drives the new middle classes and what kind of status is actually aspired – is it the classic income-signalling or are there possibly " international hipster"-types of status signalling that entail other kinds of products, decisions and lifestyles? Here, some interactions with social norms can be expected as decision-making of an individual tends to be guided by the peer groups and influencers around a person (eg if no one saves energy why should I?). Remittances may also play an important role here in determining both social norms in groups and aspirations, especially if returnees from working overseas start investing in local assets or transmit ideas, values and practices (social remittances; Levitt 1992).
The outer layer of the onion is particularly important for understanding the livelihoods in middle income countries. Efficient technologies may or may not be available. The infrastructure determines what kind of choices are actually realistic for the consumer. The policies and regulatory environment such as the availability of energy efficiency labels or energy pricing determines the general decision space for middle class consumers as well.
This heuristic model is lean enough to be applicable - due to the focus on new middle classes' carbon consumption – and comprehensive enough to explain decisions in more than one specific context. The paper will explore its content and potential variations across different cultural context, taking Ghana and the Philippines as examples.

2. METHODS

The explanatory power of the analytical framework will be illustrated using both quantitative and qualitative data for Ghana and the Philippines. The relevance of income and remittances will be discussed using data of the Ghana Living Standards Survey (Round 7, 2018) and the Philippines Family Income and Expenditure Survey (2014). These surveys include information on asset and expenditure structure of middle classes, including energy. For assessing the impact of status and social norms as well as the contextual factors technology, data will be complemented with insights from semi-structured expert interviews and focus group discussions with middle class members of both countries. Interviews were conducted in the Philippines in December 2017 and the focus group discussions will be conducted in July 2018 in Manila. The qualitative interviews and focus group discussions in Ghana were conducted in March 2018. The focus groups treat questions on energy and transport behaviour, attitudes, norms and lifestyles of middle class members.

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STIMULATING ENERGY-SAVING BEHAVIOUR THROUGH ECO-FEEDBACK, ADAPTIVE GAMIFICATION AND PERSONALIZED RECOMMENDATIONS

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Keywords: Behavioural change, Energy saving, Visualization, Gamification, Recommender system

1. INTRODUCTION

The use of IoT technologies (e.g. smart metering, smart home) and persuasive techniques to support energy-saving behaviour in households has been increasingly researched. Studies suggest that effective designs of such systems should incorporate different types of feedback with motivational techniques and energy saving advice [4]. But to be effective, these must consider different consumer types and needs, be presented at the right moment and provide actionable suggestions, tailored to a given user and context [3]. While such approaches are little investigated in this domain, we describe how we pursue that in the EU-funded project enCOMPASS (Grant Agreement no. 723059) [1].

2. APPROACH AND DESIGN OF THE ENCOMPASS END-USER APP

The enCOMPASS project [1] investigates how the integration of eco-feedback with gamification elements, personalized recommendations of energy saving actions and incentives adapted to different user types can stimulate changes in energy consumption behaviour. While the project addresses different building types, here we focus on the household scenario. The design of intuitive feedback on the consumed energy in the enCOMPASS end-user app takes into account that different categories of users may favour different types of visualizations. Firstly, metaphor-based visualizations are employed to relate abstract concepts to metaphors from everyday life. Secondly, for more data-oriented users, a data-driven bar chart allows detailed inspection of the consumption at different time scales. A battery metaphor is used to show the progress of energy consumption for a given month in relation to the same month of the previous year (historical comparison), and in relation to a (modifiable) savings goal suggested to the user (goal setting). The battery metaphor also communicates the notion of energy as a limited resource that should not be wasted. The impact of the achieved energy savings is also shown on three different dimensions: the monetary savings, the environmental impact (CO2 emissions) and the hedonic value (user's gamified achievements). The monetary impact is visualized with a piggy bank metaphor, the environmental one with a number of trees corresponding to saved CO2 emissions, and the hedonic one with jars filled with candies and badges collected through the obtained savings. The choice of these dimensions and the design of the visualizations have been informed by the goal-framing theory that identifies several motivational goals as drivers of pro-environmental behaviour [2]. To improve the users' capability of saving energy, which can increase the behavioural intention to act, energy saving tips are provided in a static (browsing) and in a personalised manner (recommendations). Personalised recommendations consider the size of the household, the observed energy consumption, available appliances, in-home sensor data and presence patterns (temperature, weekday, hour). Based on this, the recommender prototype chooses which energy saving tips to present to whom and at which time. The recommendations are delivered as mobile notifications in the given time slots (in the first version chosen from predefined settings). To nudge users to read the recommendations, gamified elements are used (points and badges). To increase the likeliness of acting upon the recommended saving tips, personalized incentivization messages are given. Based on user responses to different motivational drivers, obtained in a sign-up questionnaire, the corresponding incentive message (money, environment, hedonic) is appended to the recommendation (e.g. "Decrease heating when leaving. This will help protect the environment.").

3. FORMATIVE EVALUATION OF A PROOF-OF-CONCEPT PROTOTYPE

Results of a formative evaluation of a proof-of-concept prototype app in an alpha test with 14 users suggest the suitability of the developed concept: most users found that the app would be useful in their daily life (10/14), and that it would motivate them to save energy (12/14). The different visualizations were also well received: all participants stated that it would motivate them to see how much money they could save (11 somewhat, 3 very motivated), and how much CO2 they could save (idem). They perceived as motivating to know the development of consumption information over time (detailed chart: 10 somewhat, 3 very motivated), the comparison against a historic baseline (detailed chart: 8 somewhat, 3 very motivated), and the comparison against a concrete goal (battery visualization: 8 somewhat, 2 very motivated). Energy saving tips were also perceived as motivating (9 somewhat, 3 very motivated), while responses to gamification elements were mixed: 6 participants felt motivated by points and badges (3 undecided, 5 negative), 8 by tangible rewards (1 undecided, 5 negative) and only 4 by the leaderboard (5 undecided, 5 negative). One reason for that could be the very short time of app usage in a test setting, which made it difficult to get a real sense of competition or achievement. Another limitation is that the personalized recommendations and adaptive incentives could not be tested at this stage, though their mock-ups were well received in previous workshops.

4. CONCLUSIONS AND FURTHER WORK

The evaluation of the proof-of-concept prototype suggests the suitability of the overall design, but must be taken with caution due to the mentioned limitations. The impact of the enCOMPASS app on users' energy consumption and antecedents of behavioural change will be assessed during 14-months of real-world usage in pilots in three different countries (D, CH, GR) which started in June 2018.

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QUALITATIVE CLASSIFICATION OF ENERGY CONSUMING HABITS OF YOUNG HOME OCCUPANTS.

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Keywords: Energy efficiency, User-centered Design, Habits, Comfort, Home

1. INTRODUCTION

Two main strategies have generally been used for tackling energy reduction: one dealing with the design and development of building systems and appliances that are engineered to be as efficient as possible while meeting standards, the other addressing the user, usually through campaigns, advertisements, or physical interventions, with the expectation of changing behaviours into more sustainable ones [1]. Nevertheless, behavioural change and energy savings through such approaches has not been decisively achieved, presumably due to the intangibility of both the end results, which are health, comfort, and energy savings, and to the fact that generally, the home environment and the energy consuming products within are not designed to support the occupants' cognitions and behaviours [2, 3]. In recent years, it has been shown that occupants' "habits" are the main culprit behind inflated home energy usage [4]. Habits are particular types of behaviour that due to their unconsciousness and automaticity, have been understudied. Habits are particular types of behavior that due to their unconsciousness and automaticity, have been understudied [5, 6]. Based on psychological and behavioral research, habits are cue and context dependent behaviors, which happen automatically and unconsciously, that are learned through the obtention of a reward, achieved by the habit itself [7]. Therefore, habits are forged by the need of controlling and obtaining rewards, achieved through a behavior –the habit itself- and that is triggered by an environmental cue. As the behavior becomes more frequent, and automatic, it becomes a habit.

2. MATERIALS AND METHODS

A workshop was carried out as a pilot to classify the habits of master students. The objective of the study was to find types of energy consuming habits by a young population. Architecture master students of the Delft Technical University, were invited to participate in the workshop. This was done by sending them a link to fill out a specially developed survey. The workshop had six steps: first, identifying general home expenditure behaviours at home. Secondly, identifying an energy consuming behaviour repetitive in nature. Third, identifying the reward that the behaviour brings. Forth, identifying the cue that triggers the behaviour. Fifth, deliberating whether one of the elements of the habit could be changed. Sixth, brainstorming systems that would allow for the same reward, while allowing for a behaviour that is less wasteful. After the workshop, the forms filled out by the participants were analysed, and the routines were grouped by type.

3. RESULTS

85 people filled out the initial survey, from which 66 participated in the workshop. The mean age was 23.9 (21-30). 91% of them were renters, and 60% lived with housemates, 9% with their families, and the rest alone. 70% of them had been living in their current house for less than 3 months, since this was a newly started semester, mainly with freshly arrived international students. 57% of them resided in an apartment, of which 90% was situated in the Hague-

Rotterdam region. Of the 66 participants who finished the workshop, 48 unique habits were specified by the students. The habits were written into sticky notes and categorized into groups. After several iterations of this clustering procedure, a final number of routine groups was found. Eight types of habits were found: forgetfulness, water use, thermal habits, cleaning habits, cooking habits, personal care habits, relaxation habits, and hobbies. The eight types of habits are presented in Table 1 with examples of their comprising behaviours.

Routine Groups	**Example of behaviors**	**Number of people**
forgetfulness habits	Leaving lights on; forgetting laptop on, forgetting other appliances on, etc.	10
water use habits	Long hot showers, using washer at low capacity, dishwasher at low capacity, etc.	10
thermal habits	Turning on a/c in any season. Having heating on all year. Opening windows when HVAC on.	5
cleaning habits	Using vacuum cleaner for smaller tasks.	3
cooking habits	Boiling water, microwave use, oven usage,	10
personal care habits	Air purification, AC use for dryer air, etc. Several sequential routines in the mornings.	6
relaxation habits	Social media use all day on laptop, music on all day to avoid loneliness, radio on for background noise, binge watching TV for avoiding boredom, game console, etc.	11
hobbies	Playing instruments, watching one movie every evening, skyping with people, etc	4

4. DISCUSSION

The strength and limitations of this study are varied. Firstly, this workshop shows promising results to apply it as a small-scale focus group, whose results should be supportive of the results of a survey carried out with 900 respondents. It also shows that the habits of this particular population are ultimately simple to categorize into heterogeneous groups, due to the habits distinctness. The advantage of having knowledge about these habits, specifically when combined with the results of a survey can help for the design and development of home products that will better support the users' needs and motivations, so that energy savings are achieved in a more successful manner. However, focus groups in small groups have to be carried out for this, while also combining the results of such a qualitative study with that of a quantitative one.

5. CONCLUSION

This workshop enabled the finding of eight distinct types of energy consuming habits by students of architecture in the Netherlands. The study served as a pilot for carrying out focus groups with a similar goal. Thus, the study will serve to cross-verify the results from a previous, quantitative study. The objective of this is to classify occupants based on their behavioural patterns, which in its turn is a requirement for the development of tailor-made energy consuming products and systems, which, though their characteristics, support the users' needs and behaviours.

6. ACKNOWLEDGEMENTS

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FOSTER URBAN INNOVATIONS THROUGH COLLABORATIVE DIALOGUES – MALMÖ INNOVATION ARENA AS AN EXAMPLE

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Keywords: Collaborative dialogue; collaborative planning; experimental governance; property owners; property developers; energy efficiency, low carbon city district

1. INTRODUCTION

Malmö, the third largest city in Sweden, has spent the last five years in an intensive collaborative dialogue process to create an innovation arena supporting a sustainable development for the city. In 2013 the innovation platform 'Malmö Southeast' started to identify barriers to innovation and sustainable urban development. The overall challenge found by the platform was that the physical urban development processes in Malmö were not used to a sufficient extent to stimulate, develop and disseminate innovation. When Malmö Innovation arena was established the purpose was to be a catalyst and an arena for innovation that takes as its starting point to overcome the barriers identified in the platform.

One barrier found in the first phase was a low interest from property owners and property developers to do investments that contribute to social, ecological and economical sustainability. Large parts of the physical space are owned by public and private property owners and they need to be involved and engaged in sustainable urban planning processes to have high ambitions regarding sustainability also implemented.

One project within Malmö innovation arena is a development project in one city district in Malmö called Sege Park. Sege Park is a former mental hospital area that was closed in 1995. The idea is to develop the hospital area into an area with a mix of new and old housing, business, public services and public parks. In 2025 the idea is to have up to 800 dwellings in the area. The development process was said to be characterized by a sustainable approach with specific focus on energy efficiency and creating a low-carbon district. According to the website Sege Park is supposed to be a frontrunner in sustainable urban development and it is supposed to be a test bed for sustainable solutions such as carpooling, self-sufficient street lighting, integrated recycling.

The aim of the presentation is to show the results from an ongoing literature review on property developer dialogues, present experiences from the developer dialogue in Sege Park and discuss a tentative framework for how collaborative dialogues can be developed as a way of governing urban innovation and foster sustainable built environments.

2. TENTATIVE RESULTS FROM ONGOING RESEARCH

Malmö signed in spring 2017 a contract with 13 property developers in the area of Sege Park. Swedish municipalities do not have the authority to regulate the technical properties of buildings. As a way to still succeed in creating this frontrunner in sustainable urban development Malmö has initiated a developer dialogue with the contracted actors in the area, building on the city's previous experiences with dialogues in the development of sustainable districts. The purpose with the dialogue in Sege Park is to agree on strategies and procedures to test different sustainable solutions and in the end to reach energy efficient solutions and a low carbon community.

We have followed these developer dialogues since they started in August 2017. This kind of dialogue has been used in Malmö since 2004 with various results. Smedby has in her thesis [1] discussed the outcomes of several of these dialogues, showing for example that the dialogues have contributed to an increased engagement in achieving ambitious sustainable goals, but have not in the same way contributed to developing innovations.

The dialogues provide the developers to sit at the discussion table and pinpointing everything from budgetary issues, community visioning, and sustainable policy goals. The dialogue is a collaborative way to develop low carbon city districts and an alternative to confrontation or top-down decision making. There are of course also pragmatic reasons for the city to use a dialogue. Power is fragmented and it is hard also for powerful agencies or developers to produce results they want on their own. Cooperation is simply needed.

Innes and Booher [2] recognize that these dialogues usually need to start from scratch, starting with trying to understand each other and what values and objectives different participating actors bring into the dialogue. We have done interviews and observed how the dialogues in Sege Park are conducted in practice during the meetings. We have seen that it often is the municipal administration that is leading the conversation, setting the agenda and define which problems and solutions that will be up for discussion. We have also observed what values that are expressed and if there are values that are taken for granted or even concealed. These observations will be the fundament to discuss a framework for how collaborative dialogues can be developed as a way of governing urban innovation and foster sustainable built environments.

3. CONCLUSIONS

The developer dialogues have become more or less an institutionalized part of urban development planning in Malmö. They are often highlighted as one of the success factors for building the city's sustainability brand, while at the same time they have been encountered many challenges. To have a dialogue fulfilling the purpose to create innovation and sustainable solutions needs a theoretical framework that involve a narrative including methodological pluralism and coevolution of different perspectives. We will present our findings from an ongoing literature review of earlier research on collaborative dialogues. This, together with our results from the property developer dialogue in Sege Park will be the basis for a tentative framework to be discussed at the conference.

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KOSHER ELECTRICITY: (RE)CREATING A SUSTAINABLE SHABBAT FROM THE MIDDLE OUT

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Keywords: Middle actors, Middle out, Kosher electricity, Energy services

1. INTRODUCTION

According to the 'Halacha', the Jewish codebook, it is forbidden for people to turn lights or any electrical appliance on or off during the Shabbat (which lasts from Friday after sunset to Saturday after sunset) and during religious holidays - a total of about 60 days a year. This prohibition is a 20th century addition to observant Jews’ rules of conduct and relies on the Old Testament's prohibition of lighting fire during Shabbat. In modern life, in which so many of the daily services are supplied by electricity, such prohibitions make the functioning of the household complicated and often impossible. The commonly applied solution is the 'Shabbat timer', which during the Shabbat automatically turns on and off lights and appliances in pre-defined hours. For example, the timer could be set to turn lights off on Friday at 11pm and turn them on again on Saturday at 8am. This practice is acceptable and used by most of the observant Jews.

An additional concern raised by several ultra-orthodox groups regards the use of electricity that generated in power plants by Jewish workers and for the benefits of Jews on Shabbat. This is a problem because doing any work on Shabbat, not for the sake of saving peoples’ lives, is a strong violation of the Shabbat and thus strictly forbidden. Following this violation of Shabbat, the late leader of the ultra-orthodox group – the 'Misnagdim' – ruled that his followers should detach themselves from the electricity grid during the Shabbat, as the electricity grid is non-Kosher. Accordingly, every Friday just before sunset, approximately one quarter of a million people, in about 50,000 households, voluntarily disconnect themselves from the electricity grid and instead connect to polluting, noisy, expensive and often unsafe diesel generators or consume electricity from batteries – until Saturday after sunset. Once a generator is on, no person allowed changing or amending its operation. Often, the Shabbat follows or is followed by a religious holiday, in which the same 'kosher electricity' rules apply. This means that the disconnection from the grid is longer than 24 hours, and could last even 72 hours. The disconnection practice negatively affects the comfort and well-being of this relatively poor group, and in particular, those connected to batteries.

While most religious groups in Israel agree that working during Shabbat in power stations is considered a ‘life saving’ action, the Misnagdim disagree. Various attempts made to resolve this issue and find a sustainable solution, i.e., a solution which is economic, environmentally friendly and one that improves the well-being of the Misnagdim. These efforts included the involvement of parliament members, the ministry of energy, the ministry of the environment, the regulator, the Israeli Electricity Company (which until recently was a monopoly in power generation), as well as others. Despite these efforts, no solution was acceptable by all actors.

The 'Committee for matters relating to energy-use on Shabbos' (hereafter ‘the committee’) was formed a couple of years ago by the 'Misnagdim' leading figures, with the aim to solve this issue for the benefit of its people, and with the understanding that for a solution to be acceptable it needs to be sustainable. Essentially, the committee is a unique type of middle actor that tries to reach an acceptable solution in a highly disputed reality by acting from the middle out.

2. DATA COLLECTION AND ANALYSIS

The ongoing research reported here applies the middle out framework [1],[2] to explore and analyze

various roles the committees fulfil and the impact it has on the Israeli energy arena in three directions: upstream (on the Israeli electricity regulation), sideways (on the Israeli energy private sector) and downstream (on the norm of electricity consumption during the Shabbat).
For doing so, various methods for data collection have been used, including (1) interviews with official decision makers, people from the committee, the Israeli Electricity Company and experts from the academia; (2) a revision of formal and non-formal published documents and correspondence between actors in the field; and (3) participation (as observers) in forums in which the matter elaborated and discussed.

3. PRELIMINARY FINDINGS

The committee is a unique middle actor in the Israeli energy arena: it does not seek profit, it has no interest in the environment, none of its members is a professional energy expert, and its sole interest in the energy world is the provision of kosher electricity to its members. However, the committee understands that in order to promote any solution – this solution needs to be sustainable, economic viable, and politically and publically acceptable. For this, the committee needs to build a strong supporting network and to collaborate with as many actors as possible.
To understand the socio-technical environment and the many difficulties surrounding the discussion about Kosher electricity, as well as the reasons for future success or failure of any proposed solution, the social, political, cultural and technical Israeli contexts must be considered, including:

1. There are growing tensions between the secular and ultra-orthodox regarding the separation of church and state. These tensions make it hard to reach a consensual solution in matters related to religion in general and the Shabbat in particular.
2. The ultra-orthodox segment of society is fast growing due to high birth rates and is expected to rise from 11% in 2015 to 20% by 2040 and 32% by 2065. Thus, a valid solution is one that could be scaled up sustainably.
3. The unique Israeli electricity grid is not connected to any of its neighbors and operates as a standalone electricity island. Hence, the option to import electricity during the Shabbat is not valid.

In its search for a widely supported solution in such turmoil environent, the committee fulfills three main roles: aggregator, mediator and translator. It aggregates its' public demand for a kosher electricity, bringing authentic voices from the 'fields' to the energy policymaking arena. It mediates between the conflicting demands of the various stakeholders, trying to build a coalition of supporters and promote Kosher electricity as a win-win solution to all. And lastly, understanding the religious Shabbat restrictions on the one hand and the regulations of the energy markets on the other hand, the committee acts as a translator for decision makers, community leaders and the public. These unique functions and roles allow the committee to act effectively sideways and upstream.
The presentation focusses on how the committee promotes its preferred solution – an array of 'peaker power plants' located near areas and cities populated by Misnagdim. While these power plants will run on natural gas during week days serving the national electricity grid, during the Shabbat and high holidays they will be disconnected from the electricity and gas grids, operating automatically with no human involvement in an 'island mode', and fueled by liquefied natural gas (LNG). Such a solution requires the support of the ministry of energy, the regulator, the electricity company (responsible for the electricity distribution networks), the natural gas distribution companies, and LNG providers.

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Contribution to the special session: "Understanding and fostering citizens' energy-saving behaviour through collaboration between science and cities"

Dynamic & participative process towards sustainable development on city level with focus on sufficiency

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Keywords: governance for sustainable development, context management, societal learning, sustainable consumption, participation

1. INTRODUCTION

In the discussion on sustainable consumption patterns, government and business representatives often argue with the free will of the consumer or the voter. The understanding is that the predicament of overconsumption can only be overcome if the values behind the present lifestyles change; to this end consumers may be informed and educated but not coerced (Sanne 2002). Although it may appear that it is ultimately about the consumer's decision, but to describe this decision as "free" goes beyond reality (Sanne 2002). The way people implement energy-related practices depends not only on attitudes and knowledge, but also on highly interdependent socio-technical networks and supply systems (Sanne 2002, Lorek & Spangenberg 2013, Akenji 2014). Responsibility for energy-saving behaviour does not therefore rest with the consumer alone; business, politics and administration make a decisive contribution to the success of development towards sustainable consumption behaviour (Spaargaren 2011).

A major challenge is that direct control of individual behaviour is generally not rewarded politically nor can companies be expected to evade the principles of the market economy (Sanne 2002). The way out of the responsibility trap, into which the consumer is pushed, could be a societal appropriation and learning process (Kemp, Loorbach et al. 2007). The process is important not merely for changing people's consumption behaviour but even more in building demand for, and acceptance of, political decisions and innovative alternatives towards sustainable consumption and energy-saving behaviour (Akenji 2014).

2. METHODS

In order to investigate this appropriation and learning process, we have developed an Internet-based software that enables a participatory process that is oriented towards the specific goals of urban development in each city. We call the intervention "dynamic & participatory sustainability process". The software enables the integration of relevant stakeholder groups (in our case citizens, executive, legislative, business and civil society organisations (CSO)) into a dynamic evaluation process of urban development. In a transparent way, users can compare the constantly evolving level of measures with the relatively static target level and develop a transparent and credible overview of urban development. The data collection takes place on the one hand through the evaluation of data that can be collected through the use of the online tool. These include, for example, user behaviour and socio-economic data. On the other hand, through questionnaires and interviews with stakeholders. Every user is asked to fill out a questionnaire for the base line survey. For the control of the results there will be a control group that does not work with the tool.

It is planned to include important departments of the administration of Basel-Stadt with regard to energy, mobility and housing as partners and users in the project. Positive discussions have already been held here.

At least the political parties in Parliament are invited, and it is also possible to involve every single Member of Parliament.

Two trade associations and the local energy supplier have already been asked from the "Business" stakeholder group. It is planned to ask for further companies via the trade associations and to motivate large corporations based in Basel to participate in the context of their CSR.

In the CSO Group, discussions are being held with a number of local and national NGOs and NPOs. Churches and labor unions are also invited to participate in the experiment.

It is planned for the citizens' group to write to 1000 random households in Basel-Stadt. We will form a user group and a control group among the feedbacks that agree to participate.

The study examines whether the willingness to support controversial measures among users increases if awareness of the coherence of urban development is made transparent and integrated into a participatory process. The question arises whether such a form of continuous participation can contribute to making urban development a task for society as a whole, promoting trust and sharing responsibility for successful development among the actors.

An exact formulation of the research questions and how these can best be investigated qualitatively and quantitatively is currently the subject of discussion within the research group.

3. RESULTS

We are still at a relatively early stage of the intervention. The software was developed and programmed during the past year. The test phase of the software is still running. Intervention is scheduled to begin in the fourth quarter of 2018 and to be completed in the summer of 2019. We hope that the presentation at Behave2018 will provide valuable information from the experts present on how we can further clarify the study design and the research questions. We are convinced that our approach offers a variety of interesting approaches for scientific research, only a fraction of which we can work on within the scope of this project.

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EFFECTS OF PUBLIC PARTICIPATION IN DECISION MAKING ON PUBLIC ACCEPTABILITY OF ENEGRY PROJECTS: A VALUE BASED APPROACH

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Keywords: Sustainable energy transition, Public acceptability, Public participation, Values

Introduction

Energy projects aimed at sustainable energy transition (e.g. renewable energy projects) often face public resistance. Letting citizens participate more in decision making could lead to better and more socially acceptable energy projects. In practise, however, participation procedures are often not inclusive and inflame conflicts between different groups in society [1-3]. Since there is no time to waste on ill-managed energy projects in sustainable energy transition, it is critical to understand when public participation is most likely to have its desired outcomes. I propose a value based approach to answer this question. A theoretical framework will be presented with support from examples from the literature and directions for future research.

Challenges for public participation in decision making on energy projects

Public participation in decision making is defined here as organized processes adapted by responsible actors to engage the public in assessment, planning, decision making, management, monitoring, and evaluation of energy projects [4]. Normative theory on public participation requires that different groups with different values participate and that participants are open to different perspectives [5,6]. However, even if different groups are able to participate, they may not be motivated to participate. Next, exposing people to different perspectives can lead to polarization, which hampers public participation.

Value based approach

Values are goals or ideals that define what it important for people in their lives in general [7]. Energy projects may have implications for four types of people's values: biospheric (protecting nature and the environment), altruistic (safeguarding well-being of others), egoistic (safeguarding personal resources) and hedonic (seeking pleasure and comfort) [8]. I propose that values influence public participation procedures in two important ways, namely by determining who participates and how open participants are to different perspectives.

First, people may be more likely to participate in decision making when they perceive energy projects as having important implications for their core values. Especially perceived threat to one's core values may motivate people to participate, which could explain why opponents are sometimes more willing to participate than proponents [9]. Value based approach implies that in order to get people with different values to participate, the implications of energy projects for these values need to be emphasized from the early stages of project development.

Second, attitude polarization may be stronger if attitudes are rooted in people's core values. This may lead to people providing various arguments to support their value-based position, even if these arguments are not particularly important to them based on their values [10]. It is important to identify values that underlie people's views, and to address these values in participation procedures. Specifically, value based approach implies that in order to reduce polarization, it is critical to move the discussion from facts to the underlying values, thereby creating more shared understanding among participants.

Conclusion

I introduce a theoretical framework to explain key challenges surrounding public participation, namely who participates in the first place and how open participants are to different perspectives. Initial evidence from the literature supports the proposed reasoning, yet future research needs to systematically study the role of values in public participation in decision making on energy projects.

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TAILORING CLIMATE CHANGE COMMUNICATION TO FEMALE TARGET GROUPS – AN EXPERIMENTAL ANALYSIS OF VOTING AND CONSUMER BEHAVIOUR IN SWITZERLAND

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Keywords: Climate change communication, female target group, peer effects

1. EXTENDED ABSTRACT

1.1. Introduction to the problematic

Climate change represents one of the major issues of today. Despite increasing efforts to motivate pro-environmental behaviour, only limited action has been registered so far. Numerous authors have identified faulty climate change communication as one of the main reasons for this [1]. Consequently, it is imperative to take up new lines of research in order to find out how to effectively communicate to motivate people to act pro-environmentally and thus help mitigate this key challenge of our time.

1.2. Theoretical background and research design

The objective of this research was to find out what aspects climate change communication should incorporate to motivate people to adopt pro-environmental behaviour. In order to achieve this, an analysis of human decision-making was undertaken, focusing on theories of behavioural change and communication in relation to climate change. This initial analysis showed that people are neither fully rational, nor make decisions based solely on the provided information. Rather, what is important to consider while communicating on climate change is the underlying set of values and worldviews of any group [3]. Consequently, "one-size-fits-all" strategies are inadequate. Instead, communication strategy has to be focused on one particular target group to be effective [4]. Furthermore, it should be concise and focus on a limited number of key aspects that should ideally be repeated. Moreover, the communication strategy should feature the concrete and tangible impacts of climate change that are relevant in target group's daily life and propose clear steps people can undertake to limit them. Finally, it should highlight the relevant benefits people would gain from such actions [5]. Visually, the strategy should be scannable (its main points should be easily comprehended by even skimming the text), accompanied by appealing visuals supplemented by an explanatory text to make sure that people understand their purpose. All of these aspects should, however, revolve around two main features, peer effects and local aspects, stressing the impact of climate change and the measures to counter it in the locality where people live and on people they are close to [6].

The above-mentioned paragraph suggests a conflict between the need for a conciseness and the large number of points a successful communication strategy should include. As a result, the present research decided to test three versions of the same communication strategy, revolving either around peer, local or a combination of both aspects, thus attempting to resolve this contradiction. In line with the need for specialisation, the research focused on the impacts of the strategy on female participants. The experimental design chosen was a mixed-method, three step laboratory experiment consisting of 1) a pre-experimental online survey, 2) a laboratory experiment that exposed the participants to a communication strategy delivered in the form of an online website in the three experimental versions mentioned above (control group was not exposed to any strategy), and 3) a post-experimental online survey. Selected participants from each experimental group read the strategy while being exposed to an eye tracking device. In showing the frequency of the gaze and scan-path of the vision, its application allowed to identify the most important aspects of the strategies. The effectiveness of the strategies was then tested by the variations of the answers in the surveys across time and experimental groups. The dependent variables chosen were participants' decisions in relation to their energy consumption, mobility and voting behaviour in the at that time upcoming referendum on Energy Strategy 2050, a major Swiss political commitment aiming to limit the causes of climate change.

1.3. Results of the empirical analysis

The experiment confirmed the hypotheses resulting from the preliminary literature review, namely that pro-environmental behaviour decisions are not made fully rationally and are not based solely on the provided information. Moreover, the aspects of successful communication strategies were also affirmed (scannability, tangibility, specialisation etc.). Most importantly, however, the empirical analysis showed that the peer effects-based communication strategy was the most successful of the three versions tested to motivate participants, women in particular, to uptake more renewable energy and transport options and vote in favour of Energy Strategy 2050. Concise communication strategies built upon peer effects have thus proven to be the most effective to motivate pro-environmental behaviour, especially among women.

1.4. Conclusions and further outlook

The results of this empirical analysis offer a relevant contribution to the on-going discussion on how to communicate to motivate people to act pro-environmentally. Its findings are implementable in practice and are especially relevant for actors who aim to set-up communication strategies that would motivate people, women in particular, to uptake pro-environmental behaviour, especially in energy and transport sectors. Finally, the analysis also invites for further research. Among others, further research could explore the reasons why a peer effects-based strategy is the most effective in general and in particular for women (examining the mechanisms on which peer effects operate). Alternatively, additional versions of peer effects-based strategy could be examined in detail (i.e. which frames within the peer effects-based strategy work the best and what values are the most effective to be presented for any specific target group within any particular frame).

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CONTROL TECHNIQUE FOR RESIDENTIAL ESSENTIAL LOAD UTILIZATION

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KEYWORDS: Load prioritisation, Event detector algorithm, appliance utilization, peak period

1. INTRODUCTION

Electricity usage behaviour is as a result of habitual routines consequences occupants undertake unconsciously. There is no instrument that can exactly quantify the human electricity usage behaviour. However, factors (social, economic, environmental or physical) responsible for driving the consumer's energy usage pattern can be quantified to form input variables to energy management systems (EMSs). Input variables used in most of reviewed load management systems' (LMSs') seem to lack the ability to represent the user's energy consumption behaviour and its diversified appliance usage largely.

Load forecasting, appliance scheduling techniques and dynamic pricing have been employed in EM strategies. Load forecasting and dynamic pricing mainly assist the utilities in pricing, future planning and operation of the power system, whilst appliance-scheduling method sets the household loads' time of usage during off peak-demand or low peak price periods in order to minimise demand, energy consumption and costs. Review shows that heuristic, game-theory, optimal scheduling approaches have been applied mostly to achieve appliance scheduling [1],[2],[3],[4]. These optimization approaches mainly benefit the user financially as they minimize the electricity bill. However, there are certain challenges that come with using these approaches. For instance, users' energy needs in terms of technique operation is not fully accommodated. If not fulfilled, consumers are left unsatisfied, frustrated and inconvenienced cumulating in service loss. In addition, most load approaches applied in mitigation of peak demand, electricity costs or energy usage do not necessarily coincide with the prioritisation of consumer's energy needs.

This study reviews issues affecting households' energy consumption pattern and appliance utilization, household load control techniques and current technologies cum influence on electrical system and consumers' welfare while proposing a home peak load management system (HPLMS).

2. STUDY REVIEW

2.1 Deduction & Conclusion

Studies have been carried out, however, factors influencing domestic energy consumption using either top-down approach or bottom-up approach, have not been clearly address in terms of dweller's usage pattern and appliance usage in most investigations. Furthermore, from the reviews conducted, most HEMSs are rigid in their architecture, in terms of their adaptability to the dwellers' dynamic appliance oriented energy consumption behaviour. Input variables to the HEMSs lack the capability to ideally capture the consumers' energy usage pattern because of the load profiling approaches and type of input variables employed. Probabilistic, stochastic and deterministic methodologies presented some shortcomings in their approach to characterise ECB and may face challenges in understanding the aspect of dwellers' random consumption behaviour in any load management design scheme [5].
This research work proposes the development of a HEMS model based on end-use appliance control technique embedded with an event detector algorithm that tends to reduce demand and energy consumption whilst ensuring that the consumer's needs are met to a certain degree during peak period

3. PLC MODEL DEVELOPMENT & SIMULATION

3.1 Model development

The PLC conceptualised design framework is shown in Figure 1. For the PLC model development, a system thinking mathematical logic approach was employed. This approach applies intelligence technique to examine the linkages and interaction between the central monitoring subsystem and the relay driver via the supervisory system. Simulation of the proposed system was undertaken.

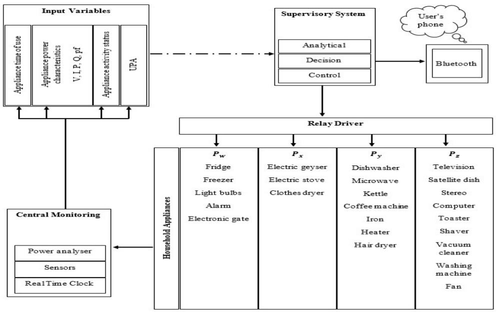

Figure 1: Peak load control system design framework

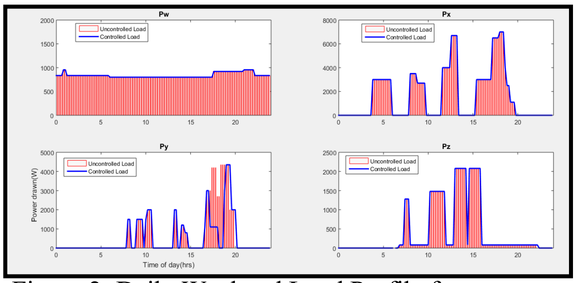

Figure 2: Daily Weekend Load Profile for proposed appliance categories

3.1.1. Simulation study – Peak load control (PLC) model system

The proposed PLC model has an embedded event detector algorithm. Load control function (Matlab user function) was used for algorithm coding. The load function reads input data from the sensors embedded within the appliance category block, UPA function and time of use (ToU) block. ToU and UPA function input data are of boolean type whereas the power characteristics measured data from category sensors is double type. During off-peak, load control is restrained i.e. any appliance can be utilised, as a result the control output switching signals are always high for activation of all categories. For both normal and controlled operation, similar demand are drawn - Figure 2. Around 4 am, gradual increase in demand – waking up and preparing for work, as shown by the rise in load in P_x, P_y and P_z. From 5am – 9am (morning peak), higher demand can be seen due to increase in appliance usage. As a result load control is being initiated, hence a sudden drop in load in categories Py at 5am; P_y and P_z controlled load curves show the respective loads being cut off within those categories at peak periods (morning and afternoon) when $P_{total} > P_{max}$. Comeback load can be seen in P_y and P_z as $P_{total} < P_{max}$ due to some of Px appliances being switched off. However, the technique control allows usage of clipped/least vital loads via UPA, hence no load comeback in some instances.

4. CONCLUSION

To address issues such as poor adaptability in HEMS due to inflexible technical architecture especially household's dynamic appliance oriented energy consumption behaviour, consumers' energy needs being neglected during design phase, a technique highlighting how domestic users' energy needs can be prioritised and fulfilled during peak periods is presented.

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IMPACTS OF DIGITAL FEEDBACK ON THE PRECURSORS OF BEHAVIOUR CHANGE: FINDINGS FROM A LARGE EXPERIMENTAL FIELD STUDY

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Keywords: Digital intervention, ecofeedback, attitudes, engagement, behaviour change, energy

1. INTRODUCTION

This paper describes results from a study evaluating the long-term effects of an innovative domestic energy feedback system. It reports on people's engagement with the feedback, and effects on their self-reported values, attitudes, and knowledge about their energy using activities and options for changing them. The results are from a five year experimental research study, the IDEAL project, a UK EPSRC-funded project that has developed and tested new energy monitoring and feedback technology and HCI designs. The results have implications for the design of smart meter In-Home Displays intended to support and encourage energy saving behaviour changes.

2. CONTEXT

Digital home energy feedback, such as that provided with many smart meters, is hoped to support and encourage occupants to change their energy using activities, as a way to reduce domestic energy demand, costs and carbon emissions [1]. However, smart meter programmes vary substantially in which, if any, feedback features are provided to occupants [2],[3].

Determining which features most influence energy using activities, and hence which would best be included in energy feedback systems, is also challenging. The impacts of feedback content and design are not easily separable. Large scale experimental field studies are expensive to run. Research typically finds impacts on final energy use vary between 0% and 15% [4], but with questions over the duration of such changes and scope for continued behaviour changes [5],[1]. Energy using activities are shaped by a number of factors, such as the daily rhythms of life, existing skills and materials, the meaning of the activity for the person and outcomes it has, their level of knowledge about their energy use and ways to change it, habit and whether existing routines are in flux due to a changing context (such as the birth of a new child, or moving home) [2]. These all shape and constrain which activities a person is both able to and willing to consider performing, at which times, and in which manners. Not all these elements are necessarily amenable to change at any given time, and vary in the extent to which a feedback system may support or encourage a participant to change them. As such, even if a feedback system leads to change in some of these elements, the activity itself may not change. Effective evaluation of the impacts of a feedback system should therefore include evaluation of changes in these important precursors to behaviour change (energy awareness, attitudes to behaviour change, etc.).

3. RESEARCH AIMS AND METHOD

This paper reports on changes in such precursors to behaviour change in the IDEAL project. Participants were recruited from in and around Edinburgh (UK) from a range of occupant and property types. Participation in the experimental study lasted between 3 and 20 months, ending June 2018. Participating homes were installed with whole house gas, electricity and boiler monitors, and air temperature and humidity sensors in each room. Participants were given a tablet pre-installed with the 'IDEAL feedback app'. Participants were randomly assigned to either a control or treatment group. A detailed description of the experimental design is presented in the following paper: [6]. Both groups initially received features similar to the requirements for a standard European Union smart meter display. This includes: dials displaying current usage and cost of electricity and gas; and historic usage and cost charts that can display different time periods, from hours of the day up to months of the year.

Over the course of the study, the control group kept the same feedback features whilst the treatment group received a range of additional new features. Participants were notified of new features via email and by their appearance in the app. New feature content and designs were developed through a mixture of drawing on existing literature, expert opinion and co-design with a subset of participating homes.

3. RESULTS

Initial results suggest that the treatment group has maintained a substantially higher and longer-lasting level of engagement with the feedback system compared to the control, in terms of frequency and cumulative duration of logins. We will report on the statistical significance of this and on the impact of this intervention on the range of other outcome variables described in the introduction, exploring which features were most used and which household and other factors influence participant engagement.

4. FINAL CONSIDERATIONS AND CONCLUSIONS

Initial results suggest that the steady release of new features combined with announcements via email lead to higher and more sustained engagement with the feedback system compared to the control group, which received no substantive changes. Further analysis of results will evaluate the impact this had on energy using activities and energy use. The results suggest that such an approach could help to counter the disengagement found among recipients of smart meter In-Home Displays, potentially increasing their eventual impact on behaviour change.

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Investigating demand-side solutions to addressing barriers in energy transitions: Study of Urban Societies in India

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Keywords: Urban Energy Consumption, Transition barriers, Well-being, Indian households, Behaviour and Habits, Social Norms

An electric car will not attract buyers unless it meets their costs and convenience needs. Induction or electric cookstoves will remain unpopular in communities that traditionally need a flame (LPG) to prepare their food. Five-star rated (most efficient) air conditioners will have limited adoption in homes unless they are more affordable. All these examples have in common that technological options for reducing greenhouse gas emissions are available, but that adoption lags if end-user preferences are not addressed.

Clearly, the transition process is missing its last link.

The income effect on residential energy consumption is well tested and understood, particularly in emerging and developing economies (Jones 1991). However, going beyond incomes, social and psychological factors such as individual preferences, attitudes, and social norms emerge as other relevant factors in determining the final energy choices and consumption patterns. This signals that the transition to low-carbon energy options is also dependent on how well demand-side solutions are integrated into the climate change mitigation framework (Creutzig, Fernandez et al. 2016). And there is no one-size-fits all solution: As choices between alternative energy services are highly contextual, a deeper understating of what preferences, habits, and practices in the appropriate contexts that shape the final demand is necessary to design suitable policy solutions.

Globally, the residential sector accounts for around 24 per cent (2010) of the total energy consumption (IEA 2017). Electricity, HVAC (heating, ventilation, and air conditioning), private mobility and food consumption dominate the household energy use. As incomes increase and access to energy infrastructure and services improve, decisions regarding the choice of energy appliance, travel mode, cooking or lighting fuel tend to be increasingly based on lifestyles and prevailing social practices. For medium to high-income groups, the consumption resulting from these decisions often exceeds the minimum prescribed levels. This suggests a demand trajectory towards attaining a certain quality of life that is unsustainable.

What would happen if the default demand trajectory becomes focused on useful service rather than energy consumed? This paper takes a step back and attempts to identify social and behavioral factors that drive the demand for selected energy services (transport, space cooling and cooking), and trace their relationship with underlying utility objectives of human well-being. We argue for a shift in the way we view and analyse energy demand, from the purview of end-use energy services.

To achieve this goal, we here specifically focus on the energy consumption dynamics of urban societies in Indian cities that are undergoing rapid urbanization. The rate of urbanization is projected to reach 47 per cent in 2040 and will shape the direct energy use and consumption patterns in the cities. Despite the second-largest urban population (after China), India has a relatively low level of urbanization providing high potential to influence the overall urbanization trajectory towards low-carbon cities.

We present an analytical framework with the objective of deconstructing demand-side determinants of direct energy use in households and examining the impact of a shift in energy service on human well-being. We investigate trends in transport, space cooling and cooking from national and regional survey data (National Sample Survey Office (NSSO), Indian Human Development Survey (IHDS) and Census of India) on urban households, reflecting socio-economic and demographic characteristics that code for the societal patterns in energy consumption. In addition, we extract detailed information and insights on social, behavioural and cultural aspects of household energy consumption from existing literature that is based on qualitative and ethnographic surveys conducted across Indian cities. A juxta-positioning of the quantitative and qualitative results provides a contextual understanding of the correlation between the factors that influence demand associated with achievement of well-being. At the same time, it is expected that indicators of well-being could in turn emerge as transition barriers to low-carbon energy use. The extent of the respective impacts – change in energy demand on well-being and a consequential change in well-being on energy demand – would determine the final rate of transition. As the main result, we present energy demand trajectories for specific energy end uses that are focused on useful energy; we also differentiate between different kinds of roadblocks towards realizing this vision across technologies and discuss fine-tuned transitioning pathways.

The evolving synergies between energy consumption, human well-being and barriers to transition generates a systematic perspective to the ongoing discussion on energy transitions. Additionally, the findings from this study present the theoretical groundwork for larger ethnographic and empirical studies to capture the social and behavioural aspects energy consumption.

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BEHAVIOURAL CHANGES TO ALLEVIATE ENERGY POVERTY IN EUROPE

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Keywords: Energy Poverty, market segmentation, pilot action, behavioural changes

1. INTRODUCTION

Energy Poverty is one of the main social, technical and legislative issues of the present time in Europe, with an estimated number of affected people ranging from 50 to 125 million ([1]). The European Commission (EC) has put a lot of effort to solve this issue, as shown, for example, by the recent launch of the EU Energy Poverty Observatory in January 2018 ([2]). One the points stressed by the EC is the importance to learn from the experiences and best practices carried out in the different Members states (MS). With this in mind, ASSIST 2GETHER project (funded by EU Commission under Grant Agreement n. 754051), of which RSE is a partner, aims to find some best practices and recommendations to address Energy Poverty from the implementation of a series of pilot actions with a group of advisors (called HEAs – Home Energy Advisors); such advisors are specifically trained to implement the pilot actions by educating energy vulnerable consumers (VCs) to optimize (and, possibly, reduce) their energy consumption, mostly through behavioural changes. In the project, RSE is responsible of the technical training of HEAs and the pilot actions planning. This paper collects the first results of the above mentioned tasks.

2. ENERGY POVERTY MARKET SEGMENTATION

The first part of the paper summarizes the results of a statistical analysis performed to understand how to define an "energy poor" or "energy vulnerable" consumer, as a common European definition does not exist. The main obstacle in performing this analysis is that the data often used for standard indicators (e.g. Low-Income High-Costs) are not available in many countries, so new ways to understand what is an "energy vulnerable consumer" have to be explored. Moreover, the availability of different data in the EU countries leads to a fragmented and often "not compatible" segmentation in different Member States. To overcome this barrier, it is necessary to define the background in which the pilot actions shall be inserted (the situation in the analysed MS) and to perform an on-purpose segmentation, by analysing and elaborating existing statistics databases (e.g. [3] and [4]) to which apply similar indicators (found in [5] and [6]), compatible with the available information.

3. TRAINING OF HOME ENERGY ADVISORS

The second part of the paper briefly introduces the training that will be proposed to the HEAs, in order to show which competences are required to an HEA who wants to approach a vulnerable consumer/family and how to build them.

4. PLANNING AND EXECUTION OF THE PILOT ACTIONS

The third part represents the core of the paper, focusing on the planning of the pilot actions. This process has involved several stakeholders, through the organization of three workshops with local experts and stakeholders, massive literature reviews (e.g. by using [7] and [8]), a brainstorming with several project partners and consultancy with organizations that have already put in place vulnerable consumers actions or are actively working in the social field.. The proposed actions are assessed by analysing their pros and cons, constraints and the time and cost forecast for each of them. Finally, the outcomes of the first implemented actions are presented to give an insight of the preliminary results.

4. CONCLUSIONS AND RESULTS

The main conclusions that can be drawn are focused on the role of the Home Energy Advisor and on the energy consumption optimization that can be triggered by their advice to vulnerable consumers.
The first issue is related to the barriers that have to be overcome by the HEAs: in particular, the education background barrier, that has shown to be a pre-requisite for the success of the training, and the “trust” barrier towards energy vulnerable consumers, that needs to be clearly established by showing that HEAs act as a “third party” with no economic interest, e.g. a national consumer association or a local charity. This is also related to the last barrier, that concerns the possibility to use the “HEA qualification” on the job market.
The second issue is that, in many cases, it is almost impossible to reduce energy consumption of the energy vulnerable households. In fact, unaware of the energy-related benefits, they are already behaving in an “energy saving” mode and consuming as little energy as possible, in order to reduce their expenses. Therefore, the HEAs should only aim to optimize VCs energy consumption in order to reduce or maintain their current level of expenses, while consuming the same amount of energy (or more, thus increasing their comfort). This can be done by using energy in a “smarter” way, for example, by exploiting the different electricity price at different time of the day or by switching to a more convenient energy provider, with the help of the external experts, such as the HEAs.

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FEELING GREEN: DECISION MODES PROMOTING ENVIRONMENTALLY-FRIENDLY CONSUMER UTILITY CHOICES

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Keywords: Decision Modes, Energy Utility Choices, Consumer Psychology

INTRODUCTION

People approach judgments in qualitatively different ways [1][2], and the use of specific decision modes promotes mode-consistent choices [3]. In many choice contexts, particularly those involving tradeoffs, multiple decision modes operate in parallel to guide people’s considerations. Clarifying how variability in decision modes shapes evaluations of environmentally-friendly products or services could inform applied choice architecture interventions that alter decision processes. The present experiments examined how decision modes shape judgments about environmentally-friendly energy options.

DECISION MODES USED IN CONSUMER UTITLY CHOICES

To investigate the impact of decision modes on energy utility plan choices in 5 studies - conducted in two countries - participants indicated to what extend they used the three different modes when presented with choices between an environmentally-friendly option and a standard option. In Study 1 and 2a participants had to decide between a more expensive energy plan that used only renewable sources or a cheaper energy plan that included standard sources. The remaining studies employed a choice between a tariff where electrical consumption was capped and a standard option where electrical consumption was unconstrained. In all studies participants' decisions were regressed on the extent to which they indicated having used an affect-based (emphasizing immediate emotional responses), calculation-based (emphasizing utilitarian considerations), or role-based decision mode (emphasizing habits or rules). Table 1 outlines the results of the regression analysis.

Table 1: Effect of decision modes on utility plan choice

	Study 1	Study 2a	Study 2b	Study 3	Study 4	Study 5
Green choice	69.5%***	66.7%***	60.2%*	84.8%***	70.6%***	66.8%***
Affect Mode	1.25***	1.24***	0.49**	0.60**	0.75***	p > .2
Role Mode	0.48*	0.84**	p >.2	p > .5	0.25*	0.81***

Calculation Mode	-0.97***	-0.94**	-0.49*	p > .3	-0.33**	-0.63***
Country (N)	CH (226)	US (132)	US (133)	CH (132)	CH (442)	US (587)

Across all studies we find that self-reported use of an Affect Mode (significant for study 1-4) and a Role Mode (significant for study 1, 2, 4 & 5) were more likely to lead to choosing the environmentally friendly option. Conversely, stated use of a calculation-based mode reduced choice of the environmentally friendly option (significant for study 1, 2, 4, 5).

In study 3 we sought to establish the effects found in study 1 and 2 in a framed field experiment [4], using utility customers encountering these options through their current utility company. Additionally, study 3 explored whether highlighting different benefits of the environmentally-friendly plan would alter decision mode use and its relationship with choice: the explanation either highlighted only the financial benefit of the green option, only the benefit to the environment of the green option, or both the financial and the environmental benefits. Results show that the main effect of Affect Mode on choice remained significant ($\beta = 2.06$, $p = .001$).

Studies 4 and 5 additionally assessed whether people are sensitive to the amount of the financial benefit of the environmentally-friendly plan. The framing significantly influenced participants' decisions in study 4 ($x^2(3) = 9.325$, $p = .025$), as participants were much less likely to select the green option when only the financial benefits were highlighted compared to the other conditions. A similar but only marginally significant pattern was detected in study 5.

In two more studies we sought to establish whether consumers intuited the relationship of modes and choice and their perceptions of which modes were most appropriate for this decision (Study 6) and whether mode use could be manipulated (Study 7). In Study 6 (N=202) 84% of participants predicted that the Role Mode would increase adoption of the green option rather than the standard option, $x^2(1)=75.59$, $p<.001$. Interestingly, participants also expected the other two modes to encourage the green choice. When asked which mode was most appropriate, 79.1% of participants chose the calculation-based mode. In Study 7 (N=269) participants were manipulated into a specific mode use. Participants were randomly assigned and primed to use one of the three decision modes. Those assigned to use the role mode made more green choices (72%) than those in the other two conditions (Affect: 61%; Calculation: 55%).

CONCLUSION

Calculation mode reduce the choice of the environmentally friendly option while the other two increase it. Although people intuit this relationship for the Role Mode, people generally feel that the Calculation Mode is most appropriate for the choice context, and anticipate that use of any of the modes will lead to of adoption environmentally-friendly utility plans. However, this may be a pitfall as it prevents (e.g. policy makers) to encourage the use of the right mode(s) which reinforce pro-environmental behaviors.

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IMPLEMENTING ENERGY MEASURES IN RENOVATIONS FOR MULTI-FAMILY DWELLINGS: INFLUENCE AND PRACTICE OF PROFESSIONALS

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Keywords: Renovation, energy efficiency, professionals, middle out perspective, practice theory

1. INTRODUCTION

Sooner or later aging buildings need renovations, opening opportunities to reduce their energy use. It is important to examine existing buildings as they will continue to represent most of the housing stock in coming decades. Even if economically feasible, existing energy measures or technologies are not always implemented. My study concerns how and why energy efficiency and reduction measures, or technologies are integrated in building renovations. I followed three planning and design phases of renovations projects by a municipal housing company in Linköping, Sweden. The housing company has the goal to reduce the amount of purchased energy by 25% to 2025 (compared to 2011).
The aim of my study is to investigate the enabling or disabling of energy measures by building professionals and other actors in the planning and design phase. I focus on this phase since it is there measures to be implemented are decided upon. My research questions are: How are energy measures discussed and transformed into plans and decisions by the professionals? Is the housing company's 25-25 energy goal translated into their planning and design practice, and if so, how? Why do the professionals decide to enable or disable energy measures in the planning and design of renovations? Another aim is to test my analytical framework combining the middle-out perspective (MOP) [1], [2], [3], [4], with a practice theory approach, as developed by Gram-Hanssen [5], [6], [7] and Schatzki [8], [9].

2. METHOD AND MATERIAL

I used a case study approach and I conducted 30 semi-structured interviews with all the participants of the planning and design phase, 39 telephone interviews with the tenants and participant observations of the meetings. Additionally, I analysed related documents.

3. THEORETICAL FRAMEWORK

In the MOP it is acknowledged that change opportunities are actively driven (or impeded) by professionals in the middle. They can exert influence upwards to the top and downwards to the bottom as well as sideways to middle actors. I define the building professionals in the planning and design phase as middle actors and aim to explore their potential to enable more energy efficient buildings. I change the focus of the MOP slightly compared to its originally use. The MOP has a focus of between-organisations; however, I look at a project within a company.

Further, I combine the MOP with a practice theory approach. I use the practice theory approach to investigate the meeting practice of the middle professionals as they handle energy measures and technologies in the meetings. In an organisations different practice are integrated as for instance a meeting practice. Energy questions are just one aspect of a meeting practice, but I have chosen to delimit my study to that. I investigate the following elements holding a practice together: (1) engagement, meaning, (2) technology, (3) explicit rules and (4) know-how, habits. Different (internal and external) professionals come together forming a temporary coalition and each bringing their own work practice as well as different opinions, knowledge and expertise on how to handle energy aspects. However, these professionals meet repeatedly in this as well as similar constellations for other projects, and thus, the meeting practice is repeatedly enacted.

4. RESULTS AND CONCLUSIONS

The combination of the middle-out perspective and practice theory as an analytical framework shows great potential to put emphasis on these building professionals and further investigate their meeting practice to understand their agency and capacity of how and why energy efficiency measures are (not) taken up. The studied renovation projects set out to be renovations with a goal to reduce the energy consumption of the buildings. However, 'energy' was not included to the extend expected. The way energy questions were handled was rather elusive. The middle did have an influence on the projects but could use their agency and capacity much more. This has however not (yet) become part of their meeting practice. Energy aspects seem to have become more important in recent years but the focus on energy was more often rhetorical. Not all professionals knew about the 25-25 goal which showed a knowledge and information gap. No clear goals were set-up for each building and energy calculation evaluating different alternatives played a minor role. Know-how and experience from previous projects regarding energy measures and buildings were valued instead. The fear of rent increase and long pay-off times of energy measures prevented their implementation. Moreover, the plurality of different goals (rhetorical, financial and lack of numerical goals) was also a disabling factor.

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Dynamic tariffs: how does literacy, decision style, loss aversion and information representation influence end-users' decisions?

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Keywords: End-user decision-making; energy feedback; energy literacy; dynamic tariffs; smart grids

Introduction

Successful change towards a low carbon energy future depends not only on technical, scientific and professional knowledge but also on the ability of the average citizen to make appropriate energy-related choices. An informed and energy literate public is more likely to be involved in energy decision-making and better prepared to make related decisions [1].
Energy end-users react differently when confronted with dynamic prices, and are encouraged to adopt a more flexible consumption pattern, adjust the demand profile by reducing or increasing consumption in different time periods, shift loads operation to cheaper time periods or redefining thermostat settings [2][3]. The complexity that dynamic tariff schemes impose on end-users resulting from the combination of different time periods with different prices should be considered in the way the information is presented to them. Therefore, it becomes important to understand how end-users are prepared to deal with retail commercial offers of time-differentiated tariffs. In this context, it is expected that individuals with greater energy literacy will be more able to cope with complex information and make better choices regarding the adoption of dynamic tariffs. Moreover, end-users' decisions may also depend on their individual decision style (e.g., intuitive or analytical [4]), the degree of loss aversion [5] and on the way information is presented to them. Although the literature suggests that graphical representations improve and facilitate thinking [2], cognitive training is still needed to process visual information and turn it into useful evidence for energy decision making.
This work presents ongoing research to understand the extent to which the complexity of the information about dynamic tariffs and the way this information is displayed influences end-users' energy decision making process. In this sense, the research question that underlies this work is:
To what extent does energy literacy, numeracy and graphical interpretation capability influence decisions especially sensitive to loss aversion issues, such as the choice of dynamic tariffs?

Methods

A literature review on Behavioural Operation Research allowed to identify behavioural dimensions associated with end-user's decision making, i.e. heuristics, cognitive and motivational biases, decision styles [6]. Loss aversion (how people perceive gains and losses [7]) stands out as one of the most relevant biases in the energy-related decisions framework. For example, in the context of choosing a new electricity tariff, presenting information as potential future savings vs. surplus costs associated with present situation may induce end-users to make different decisions.
Moreover, in a dynamic tariff adoption scenario, end-users will be exposed to complex information provided by enabling technologies. In order to support energy decisions, information must be provided to consumers in a user-friendly format [8] to reduce cognitive efforts and facilitate decisions.

An on-line survey was developed with the goal of testing the influence of the decision style, loss aversion, energy literacy, numeracy and graphical literacy on the choice of dynamic tariffs. Energy literacy assessment involved a set of multiple choice questions on the Portuguese energy context and the interpretation of consumption diagrams to assess numerical and graphical literacy (bar-graphs and cost information in column and clock format were provided). The decision style was characterised based an index of 10 items developed by [9]. Loss aversion was characterised based on a coin-to-air betting game and these results were compared with the probability of changing to a new electricity tariff, when facing a "saving" or "increased cost" formulation. The survey was performed to a convenience sample of 300 higher education students, chosen to guarantee a higher literate sample than the average population, with different academic backgrounds. At a later stage, it is expected to expand the study to a representative sample of the Portuguese society.

Preliminary results and final considerations

Preliminary results show that engineering and sciences students were predominant among respondents. No statistically significant differences were found in literacy levels between different graphical formats of energy information. On the other hand, results revealed a significant correlation with high numerical/graphical literacy and the probability of changing to a new tariff with time-differentiated prices. A significant correlation was also found between the probability of change to a new tariff with the rational style, although there was no association with the different loss aversion profiles. These results may not mirror the reality of the Portuguese end-users since this sample is not representative, and therefore conclusions can only be drawn for this specific universe. However, this approach allows to refine future work.

Understanding how end-users interpret energy-related information and use it in their decision-making processes is key to design better end-users' engagement policies in the context of smart grids.

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BEHAVIORAL CHANGE DRIVEN BY SMART METERS, DOES FEEDBACK ON ENERGY USE RESULT IN ENERGY SAVINGS?

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Keywords: smart metering, feedback, behavioral insights, energy reports

TOPIC

Policies, innovation initiatives, living labs, interventions, social practices, case and real world studies and their evaluation

ABSTRACT

In a meta study, ECN analysed the available empirical data for energy savings in households using energy feedback systems.

We started with an overview of European knowledge, and zoomed in on the Dutch situation. For five different modalities of giving feedback on energy use (in-home displays, smart thermostats, websites, apps and reports), ECN determined the quality of the empirical data by looking at sample size and representability, the experimental set up including control groups and corrections for covariance, and the duration of the experiment.

In addition to that we appointed eight functionalities of feedback like price related feedback, norm setting, visualization and gamification. Research with realtime pricing and time of use tariffs were excluded from this study.

Our results reflect the findings from the Dutch case studies as well as an extrapolation of research done abroad, and showed that highest energy savings (5-6% of total energy use) can be reached by delivering feedback via in-home displays, whether or not coupled to a smart thermostat. Websites and apps yield 2-4% savings. Empirical data show that delivering feedback reports to households in the Netherlands currently yield 1%. We emphasize the huge potential for improvement in this field, especially when behavioral change tools like visualization of energy use, gamification and setting goals and norms are implemented.

Building on the fact that feedback on energy use, provided by the energy companies in a report, is the only opt-out instrument available on the Dutch market, and thus is delivered to every household with a smart meter, ECN advised on implementing behavioural insights to improve the energy report in order to save energy. This improved feedback will be monitored and evaluated during the course of 2018. In September 2018 we expect to present the first results of this monitoring.

DEVELOPMENT OF A DIGITAL SOCIAL MARKET TO PROMOTE SUSTAINABLE AND ENERGY EFFICIENT BEHAVIOUR: LISBON PILOT

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Keywords: Citizen's engagement, behaviour change, Digital social market, Efficiency

1. INTRODUCTION

Urban areas are growing in size and population, leading to challenges related with demographics, climate change, energy consumption, transportation, etc., jeopardizing the resilience of urban systems and social wellbeing. Several solutions and city planning strategies have emerged to overturn them and promote the sustainable development of cities, focusing on changing behaviour towards energy efficiency improvements. An effort has been made to evaluate smart cities [1][2], however these are mainly focused on the implementation process than on the effectiveness of the outcomes [3]. While the assessment of city approaches and their impacts outcomes provide insights on smart city evaluation, they do not take into account the inputs from citizens even though they recognize their crucial role in the design of measures [3][4].

2. SHARING CITIES PROGRAM

The Sharing Cities Lighthouse program, ambitions to achieve a wide scale deployment of smart cities solutions, aiming to demonstrate and assess how the innovative use of technologies can improve city life and the lives of its inhabitants by promoting the active engagement of citizens. The program ambitions to improve urban mobility, energy efficiency in buildings and carbon emissions by successfully engaging citizens in the transformation of their living context and fostering local level innovation. People play an important role, however changing their behaviours can be a slow process. As such, a shared service model, enabling the creation of new urban services and incentivizing behaviour change by valuing and rewarding positive behaviours and choices related with energy efficiency, mobility, building retrofit, combining physical and digital environments is being developed: Digital Social Market (DSM) (Figure 1). This approach will benefit citizens and bring communities together, fostering closer relationships among all members: citizens, retailers, community. The work will present the DSM concept and its application in the city of Lisbon, and results from Focus Groups performed with the participation of citizens and potential users of the DSM.

3. DIGITAL SOCIAL MARKET

The DSM was developed based on previous insights gathered in a user research framework and design workshops involving city representatives, partners and citizens. Within the DSM the citizen will be able to voluntarily engage in the marketplace taking advantage of its services and making choices based on common causes, incentives and/or reward mechanisms (Figure 1). This will play a crucial role in behaviour change promoting the adoption of innovative mobility options and of energy efficient behaviours at home. The concept of DSM will be developed as a solution/tool that can be replicable and scaled up to other communities, districts, cities, countries. As such, to develop and deploy the DSM as tool that incentivizes smart city initiatives, it is essential to identify the different

needs, preferences and expectations of each of its players, including the citizens.
One of the actions taken to involve citizens in the creation of the DSM was to apply a qualitative research method: Focus Group technique. A total of 3 focus group sessions were conducted with a total of 14 participants, in which citizens were asked about their perceptions and opinions on the DSM concept, how it could promote behaviour change, behaviours related with mobility and energy consumption, etc. Participants were recruited bearing in mind that they should reflect the demographics of the demonstration area (e.g. gender, age, employment status, etc.) but divided in heterogeneous groups to ensure a good mix of ideas and perspectives. Based on the information collected it was possible to organize it in several categories: Dissemination and acceptance of DSM; DSM characteristics; Benefits for participants and; Causes. Overall the citizens had a positive acceptance of the DSM, however, it is essential to show citizens its usefulness and the educational process to promote behaviour change and decision-making towards sustainability. Due to all the factors and variables involved, it must be transparent, simple and easy to put into practice.

4. CONCLUSIONS

DSM will be a vehicle of change not only in what concerns people's behaviour but also in the overall functioning of the city, leading to more sustainable living context with decreases in energy consumption and pollutants emissions and to the improvement of citizen's quality of life. The DSM will integrate existing and new solutions for communication and dissemination purposes and, most essentially, to educate citizens. Furthermore, it will enable developing new services building upon existing systems and platforms, incentivising the sharing of data among its participants, whether these are residents or tourists. The Lisbon Pilot will be implemented in high schools, that will work for the achievement of a common cause, requiring not only the involvement of students, teacher, staffs, parents but also the participation of all the community.

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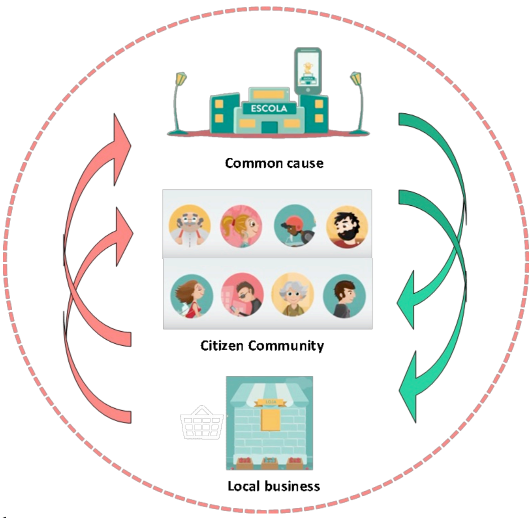

Figure 1 – Digital Social Market structure

ENERGY SAVING KITS – EDUCATING AND EMPOWERING END USERS?
A Cross-Country Case Study Comparison

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Keywords: Demand-Side Information, Energy efficiency, Behaviour, Residential, Energy Saving Kits

EXTENDED ABSTRACT
There are many ways to approach Demand-Side Management (DSM) and Demand-Side Information (DSI) programmes, from the rather complex (e.g. smart meter and energy feedback device data) to the rather simple (e.g. social media campaigns). This paper formed part of a special session on "recent developments in DSM and DSI to reduce energy consumption". The International Energy Agency's Demand-Side Management Programme's (IEA DSM) Task 24 is called "Behaviour Change in DSM" and has been studying behaviour change theory (Phase 1) and practice (Phase 2) for almost 7 years now. Here, we will focus on a residential case study in Ireland that uses Energy Saving Kits in an attempt to educate and empower Irish householders on their home's energy performance. We will also present an international case study comparison of similar programmes, based on interviews with programme managers in Canada, Australia, the US and New Zealand.

Task 24 has tested the usefulness of a "Collective Impact Approach" (CIA) [1] in field research settings, including the one described here in Ireland. This approach is premised on the belief that no single policy, government department, organisation or programme can tackle or solve the increasingly complex problems we face as a society. The approach calls for multiple organisations or entities from different sectors to compromise on a common agenda, shared measurement and alignment of effort. In addition to following the CIA, a "Behaviour Changer Framework" [2] was created to provide an overview of the social ecosystem, focusing on all relevant stakeholders, i.e. the *Behaviour Changers* from the different sectors and their relationships with one another, and the *End User*. This approach was used to guide the development of a collaborative field research pilot using public libraries to loan out Energy Saving Kits.

Public libraries have been used as "Middle Actors" to loan out Energy Saving Kits since the early 90s, when the idea was first implemented in Southern Australia. There are now many such programmes, especially in the English-speaking world, and they are generally regarded as highly successful – despite lack of measuring direct behavioural outcomes or impacts. A typical Energy Saving Kit, such as in Ireland, contains 6 measurement tools to assess current energy use, or determining/fixing the (in)efficiency of: **heating** (radiator key), **appliances** (plug-in energy monitor), **insulation** (thermal leak detector), **fridge/freezer** (fridge thermometer), **thermal envelope** (digital thermometer and humidity metre), **water** (stopwatch to measure water flow in e.g. shower). Some of these tools are very simple to use (e.g. stopwatch) and some require more reading instructions and effort (e.g. plug-in energy monitor). Some are simply to provide insights into the current situation, including showing potential issues like

leaks or draughts or energy-draining appliances which would require further investment or the call-out of professional tradespeople. Others can be used to immediately remedy a problem – e.g. the fridge/freezer thermometer or radiator key used to bleed radiators to improve their efficiency.

In addition to using a Collective Impact Approach and the Behaviour Changer Framework, we also used another Task 24 tool called "Beyond kWh" to partly evaluate the impact of the Irish programme. All programme managers interviewed regarded their programmes as highly successful, due to long waiting lists and high loan rates of the kits. However, hardly any conducted additional surveys of householders who borrowed the kits and none could point to any definitive changes in energy literacy or energy efficiency and conservation behaviours associated with the tools in the kits. The Irish programme, in addition to using qualitative surveys, focus groups and interviews to determine end user experiences with the kits, also used Pre- and Post-Beyond kWh surveys, based on psychometric testing [3],[4].

35 (out of 44 recruited) households completed pre- and post-kit surveys measuring their attitudes toward the kits themselves (e.g., perceived utility, positive experience), frequency of energy-saving behaviours (e.g., limiting shower time), and attitudes toward environmental issues (e.g., concern about ecological damage). Respondents were between the ages of 18 and 60+. The majority were home owners (n = 32), and identified as male (n = 23). In addition to evaluating the overall descriptive summaries, we analysed whether there were any pre-to-post kit differences in frequency of environmental behaviours, and attitudes toward climate change and community environmental issues. Bayesian hierarchical regression models were utilised to examine whether there were positive changes in user's energy-related behaviours and environmental attitudes when comparing their pre-kit scores to their post-kit scores.

Close to half of the participants (n = 15) used the kit for environmental reasons, and the majority (n = 26) heard about the kits from friends and family. Overall, 33 out of 35 users indicated that they would recommend the kit to others. Users had very positive appraisals of the kits, with the majority agreeing that the kit met their expectations (n = 32), made them think about their home energy use (n = 34), and encouraged them to consider replacing appliances (n = 19). The thermal leak detector was rated as the most useful tool in the kit, while the stopwatch and radiator key were the least useful. Results of the longitudinal analyses reveal small but potentially important differences between pre-kit and post-kit attitudes and behaviours, suggesting the potential for energy reduction through kit usage.

We presented the most interesting differences in Energy Saving Kit programmes in a cross-country case study comparison [5] and delved in more detail into why the Irish case study, informed by the Task 24 "Toolkit for Behaviour Changers" yielded more promising outcomes and results [6,7]. This included a step-by-step walk-through of the entire process, from identifying the issue to disseminating the work.
We would like to thank the Sustainable Energy Authority of Ireland for data collection and co-funding.

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ANALYSING THE COUNTRY-WISE PERSPECTIVES ON THE FACTORS DRIVING COLLECTIVE ENERGY CHOICES AND ENERGY-RELATED BEHAVIOUR: POLICY RECOMMENDATIONS

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Keywords: Energy behavior, formal social units, collective decision-making, policy recommendations

ABSTRACT

Social Science and Humanities (SSH) research on questions relating to the energy transition has been encouraged and requested on both the national and international level in later years. Social science research is uniquely positioned to give insights to policymakers around how relevant stakeholders make energy-related decisions and can give recommendations towards the goals of providing clean, affordable and reliable energy, facilitating a shift towards electric mobility and sustainable buildings as well as innovation that secures the European Union's position in the world markets of the future. In the ECHOES project [1], we have conducted 69 semi-structured in-depth interviews and 15 focus group studies that have taken place in Austria, Bulgaria, Finland, Norway, Spain, and Turkey. The purpose of the interviews was to come up with data that would enable us to provide solid science-based policy recommendations to the European Commission on how to achieve a stronger Energy Union and the successful implementation of the Strategic Energy Technology (SET)-Plan [2]. Thus, the overall aim of this paper is to provide comprehensive policy recommendations addressing the three levels of formal social units that are stakeholders as defined in the ECHOES project as formal social units, collective decision-making units and individuals engaging in joint contracts. Formal social units are decision-making units, which act as policy-makers and/or energy providers, with a wider reach of influencing energy choice decisions. Collective decision-making units are formally structured groups with relatively lower power asymmetries as compared with formal social units. Individuals engaging in joint contracts are individuals that engage in group decision-making processes around energy choices, so they can increase their negotiation power with other more formal bodies. Moreover, this paper also aims to provide policy recommendations relating to three technological foci addressed in the ECHOES project, which are smart energy technology, e-mobility, and buildings. We attempt to provide a systematic analysis of relevant stakeholders at each level, how these interact and communicate, and potential motivations and barriers for energy-related decision-making.

Following this, the insights from the in-depth interviews and policy recommendations addressing each level and technological focus will be presented.

Formal social units

For the formal social units, we provide comprehensive policy recommendations that address several key impact areas for improving and facilitating energy-related decision-making. The paper also highlights some country profiles acknowledging the differences in energy transition progress across Europe, as general recommendations would not fully capture these differences, although several policy recommendations have a general character. The tentative conclusions from the formal social units' level are policy recommendations surrounding three main themes that have emerged from the data material; these are regulations and support schemes, cities and local governance, and public procurement.

Collective decision-making units

When addressing the collective decision-making units level, our paper attempts to provide insights and policy recommendations relating to how collective energy-related decision-making can be facilitated and incentivized and in what way policymakers might implement policies that trigger more such decisions as Europe shifts towards a low-carbon economy. Thus, for the collective decision-making units level, our tentative conclusions point to the fact that ambitious and consistent, but sufficiently flexible, energy and climate policy can facilitate collective energy-related decision-making. We have also identified various conflicting and discouraging policies and bureaucratic barriers that hamper the energy transition. Our findings also suggest that policymakers can facilitate the shift towards low-carbon solutions by providing prioritized and tailored support schemes, increased R&D expenditure, the facilitation of joint networks such as industrial zones and chambers, as well as support for small and medium-sized enterprises (SMEs). We also suggest that policymakers to a greater degree should engage in dialog with industrial experts, various social partners, and visionary pioneers in order to increase the awareness and the knowledge about new innovations and the technological frontier.

Individuals engaging in joint contracts

For individuals engaging in joint contracts, the paper focuses on giving policymakers comprehensive, evidence-based insights for successful policy implementation and factors that need to be taken into account to maximize the potential for citizen engagement in energy-related decision-making. Thus, these insights aim to coordinate and harmonize regulation and policy instructions, and other support systems to support energy-related decision-making for individual consumers and individuals engaging in joint contracts. Our findings suggest that policymakers have several ways of influencing individuals through means such as, provide the right incentives for individuals to choose low-carbon solutions, supporting infrastructure establishment, tailored support schemes that directly mitigate some of the large upfront cost of several large investments in cases of large-scale retrofitting and charging infrastructure, in for instances condominiums or housing co-operatives. Finally, we suggest that regulations and market design have to be adopted to address an increasing level of small-scale distributed renewable energy distribution and other smart energy-related technologies.

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SWISS JEAN CHALLENGE: CONTESTING NORMS AROUND CLEANLINESS TOWARDS REDUCED ENERGY USAGE

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Keywords: households, participative methods, social practices, energy sufficiency, laundry, Geneva

1. INTRODUCTION

In Switzerland as elsewhere, there is an increasing recognition around the role of households in energy transitions and in the Swiss Energy Strategy 2050. While the view of consumption as being motivated by individual decision-making processes has dominated the environmental policy arenas thus far [1-3], social practice theories have been gaining in popularity by placing an emphasis on the social embeddedness of everyday life. In this view, practices such as washing, preparing a meal or getting around become the object of analysis, rather than individual units of technology or individual people. Practices are made up of three elements: socio-cultural context involving social norms and rules; people and their skills, competences and emotions; and the material dimension of consumption, involving products, infrastructures and systems of provision (extending [4]). Changing energy-using practices means working at the level of more than one element, oftentimes through forms of social learning in communities of practice (ibid and [5]). This paper presents the findings of a social learning experiment, inspired by social practice approaches, towards reducing the energy-intensity of laundry practices in Geneva, Switzerland. The main question is: in what way can participative methods engage households to reduce or improve energy usage in the home, with a focus on laundry?

2. METHODS

The research on which this paper is based is derived from a three-year study of social norms tied up with household energy-using practices (SNSF, NRP71). Three domains were explored in depth: cleaning and tidying; communicating and entertaining; and preparing and storing food, all tied to energy-using appliances. Following 42 in-depth interviews and a survey in Western Switzerland (n=708), the research team uncovered the significance of social norms around cleanliness and tidiness, but also the great variety of ways in which household members represent themselves as clean from dirty, and the great diversity of laundry strategies, even within the same household. How to address the need to reduce the energy-intensity of washing when faced with such diverse practices? To address this challenge, the research team partnered with a community association, Terragir, to design a participative and social learning experiment that would tackle norms around cleanliness and challenge practitioners to reduce their washing. Inspired by the work of Tullia Jack [6], the Swiss Jean Challenge involved recruiting 15 participants at a community event, offering them a free pair of jeans, and challenging them to wear the same pair of jeans for four weeks, at least five days per week, without washing the jeans throughout the challenge period. The challenge began with a briefing, which took the form of a discussion around social norms and practices, involving a reflexive stance to reconsidering laundry in social contexts. A Facebook page gathered testimonials, with a final briefing and exhibition taking place at the end of the Challenge.

3. RESULTS

The Swiss Jean Challenge led to a reduction in laundry cycles and a reconsideration of habits and routines around staying clean, for the duration of the Challenge. We noted three main phases: first, participants exchanged skills and tips for keeping their jeans clean; second, the concern for keeping clean lessened, as participants began to express comfort and satisfaction with wearing jeans over an extended period of time; finally, in a third phase, the Challenge encouraged them to rethink washing and related daily practices (e.g., wearing an apron for cooking, to avoid staining clothes, or airing out clothes on a balcony to avoid washing). Participants also expressed new ways of organizing daily life to reduce time spent on laundry, for example tidying up the house by putting clothes back in closets, rather than putting them into a wash cycle. Time, rather than cost savings, was an important consideration. Participants also found that wearing the same pair of jeans regularly did not solicit a negative response from people in their social networks, such as work colleagues or friends: people did not seem to notice that the participants had been wearing the same item of clothing regularly.

4. CONCLUSIONS

Social practice theories can inform the design of participative actions that engage everyday people in reducing energy consumption, working across three elements: challenging social norms in a public debate with a small group, sharing new competencies for “keeping clean and staying comfortable”, and introducing new material arrangements in the form of a pair of jeans or other “keeping clean” items (such as the cooking apron). Having fun and learning in a reflexive process with people, civil society and researchers seems to be a promising way forward, suggesting that collaboration might be just as good as competition in community engagement actions for changing resource consumption practices. What remains to be seen is whether the Jean Challenge will lead to sustained change over time, and if such an approach could be transferred to other energy-using practices: for example, the challenge of turning off a fridge for several weeks in the winter months, as one idea that emerged from the debriefing with Challenge participants. For the BEHAVE conference, we will be able to provide an update on whether changes to habits and routines were sustained over time, in follow-up interviews, as well as some quantitative data on time and energy savings based on estimates.

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VISIBILITY, PEER EFFECTS AND MONETARY INCENTIVE IN SOLAR PV ADOPTION IN SWEDEN

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Keywords: Solar PV; Visibility; Peer effects; Crowding-out; Diffusion

1. BACKGROUND

Interest in the use of solar energy and PV cell systems has grown steadily around the world [1]. Despite an accelerated solar PV capacity growth worldwide, PV electricity production only makes up 0.13% of Sweden's total electricity consumption in 2016 [2]. It is argued that there is much room for further expansion in the adoption of PV; however, various market and policy barriers are also claimed to be preventing such a development [3].

Within this context, several studies have identified cost to be a significant barrier for PV adoption [4], [5]. To address this, and in line with international policy trends, in 2009 the Swedish government introduced a subsidy that households could use towards the installation cost of PV. However, in recent years there has been a number of changes in the percentage of installation cost covered (ranging from 20% up to 60%), with changes made at relatively short notice. There is also an upper cap on the subsidy given out depending on the government's budget. These factors have created much uncertainty around funding that only serves to magnify the direct or hidden cost barriers for non-adopters, and which has been already identified as an important issue for further PV adoption in Sweden [3].

At the same time, studies have also revealed 'peer effects' to be a key driver of households' PV adoption in Sweden. While a critical evaluation of the subsidy packages is necessary, it is also essential to consider the effectiveness of monetary incentives for PV adoption in relation to behavioural and social aspects.

2. OBJECTIVE AND METHODOLOGY

The study aims to experimentally analyse the dynamics of solar PV adoption in relation to behavioural, social and monetary determinants. In particular, we focus on three key areas: visibility, peer effects and the role of subsidies. The project consists of a survey sent to non-adopters to quantitatively estimate the likelihood (stated behaviour) of PV adoption given various scenarios regarding the areas previously mentioned. First, the effect of visibility is studied by varying the location of the roof on which PV would be installed: either the agent's primary residence in a highly populated area, or her holiday home in a more remote location. Secondly, peer effects on image motive are studied by considering different levels of exposure to PV. Some agents may have never seen PV in their neighbourhood and for them honour would potentially be a strong incentive to be the first to install PV. This motive becomes less important as diffusion increases. For agents who live in communities where PV is extremely common, stigma from not yet installing PV could be the stronger motive. Thirdly, the effect of material incentive is studied by asking households their likelihood to adopt given a randomly selected level of subsidy. If households are purely incentivised by the subsidy, adoption should increase with the subsidy level. The interaction between the above three factors is also studied. Finally, agents' intrinsic motivation is elicited through a questionnaire on the individual's environmental identity [6].

3. RESULTS

Our results point to *peer effects* and *subsidy* as the main determinants influencing households' decisions to adopt PV. The correlations between frequency of seeing or hearing about PV and the stated likelihood to adopt is 22% and highly significant (p=0.0013), while the correlation between granted subsidy level and the stated likelihood to adopt is even higher at 48% and highly significant (p=0.0000). Both effects are also confirmed in ordered logistic regression analyses, and are robust to demographic controls.

Contrary to our initial hypothesis, higher *visibility* is not found to be a significant predictor of households' likelihood to adopt, the correlation between these variables are only 1% and insignificant (p=0.8369). Neither is visibility a significant predictor in any of our ordered logistic regressions. It appears that whether the PV is installed on a highly visible rooftop in an urban area or a less visible holiday house in a remote location does not matter for the household's decision to adopt – given that our sample consists of non-adopters, they may care less about displaying their environmentalism compared to adopters.

When looking at *interaction effects*, none are found to be significant. It is not surprising that the interaction of visibility with other variables are insignificant, given that visibility as a main effect is not found to matter. The interaction between peer effects and subsidy is not found to be significant either, suggesting that our group of non-adopters are not affected heterogeneously by the subsidy amount depending on their exposure to PV. In all, signs of crowding-out effects are not identified.

4. CONCLUSION

Given that only the main effects of peer and subsidy are found to be significant, and not their interaction, policymakers should not need to worry about increased subsidies backfiring when diffusion increases. Our results suggest that PV adoption can be encouraged through higher subsidies, which leads to higher diffusion, which in turn leads to increased peer effect on neighbouring households. Policy certainty about given (high) subsidy coverage is critical.

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Strategic communication of renewable energies and energy efficiency in an intercultural context along the example of an acceptance campaign

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Keywords: Acceptance, information, intercultural communication, pr campaign, communication management

1. INTRODUCTION

In a global and digitized world, organizational communication is becoming increasingly international. Complex topics, such as energy trends, are relevant worldwide. In particular, it is a question of adapting strategic communication to the social, political and cultural peculiarities and to plan accordingly. This lecture showcases from a German perspective the development of communication strategies for the people of Kazakhstan along the example of the Hochschule Hannover's international conceptional project with the topic "Development of an information and acceptance campaign for renewable energy and energy efficiency in Kazakhstan" with the project partners Association of Renewable Energy Kazachstan and the Konrad Adenauer Foundation (Country office Kazakhstan). The current state of research on intercultural communication was transferred to the conceptual process of strategic communication and combined with current concepts of stakeholder communication. The aim was to develop an expanded conceptualization model, suitable for intercultural communication planning for explanatory and information-intensive topics.

2. RESEARCH ISSUES

At what level of the analysis, strategy and tactics process are intercultural influences to be taken into account, especially in conception projects in intercultural teams?

To what extent is the stakeholder approach useful for the conceptual work in the international context and which intercultural characteristics and criteria should be included in the stakeholder determination?

Which specific communication strategies can be used for international acceptance campaigns?

3. THEORETICAL AND EMPIRICAL BASIS

The term intercultural communication is defined differently according to discipline and cultural space. A narrow definition limits intercultural communication to the area of face-to-face communication between members of different cultures. [1] In public communication, however, the focus is on mediated distribution. [2] For successful strategic communication, the consideration of stakeholders and stakeholder management is central. The concept of stakeholder management is based on the assumption that the success of organizations in a complex social environment depends on the relationships with all stakeholders. [3]. If we now have to deal with stakeholders with different claims about a topic (e.g. green economy), all of which are involved in specific cultural, social and medial environments, we need to work with an expansion of established conception models. [4] [5] [6] Basis of model development was case study research design according to Yin, in which existing theory is the starting point of case study research, frameworks provide direction and reflect the theoretical perspective. [7] A draft for an expanded conceptualization model is presented in this lecture.

4. BACKGROUND: ACCEPTANCE CAMPAIGN FOR KAZAKHSTAN

Kazakhstan is the economically strongest and most important country in Central Asia and has a special role in the German Central Asia policy – for example by signing the so-called commodity partnership with Germany (2012). Kazakhstan is striving to achieve an international recognition and wants to establish itself in the topic field of renewable energy. The country was the organizer of Expo 2017 with the motto "Future Energy“. The objective of the project partner Konrad-Adenauer-Stiftung (Kas) is „to make the Expo sustainable“.

5. CONCLUSIONS

- The strategic communication of complex topics in an international context requires an expanded conceptional model.
- The theoretical basis of expansion are aspects of intercultural public communication and stakeholder management.
- The process of concept development for the green economy information and acceptance campaign for the Kazakh population by a German university group showed that in particular the societal, value-based and cultural aspects need to be considered in communication.

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TOWARDS A DIFFERENTIATED UNDERSTANDING OF CITIZENS' ENERGY-SAVING BEHAVIOR

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Keywords: Energy Consumption, Behavior Change, Phase Models, Interventions

1. INTRODUCTION

Collaboration between cities and science supports the ongoing energy transition. Local authorities face the challenge of implementing interventions to support and foster a shift in citizens' energy consumption behavior while having to adhere to budgetary restrictions. A differentiated understanding of the determinants that drive behavior change towards a more sustainable energy consumption might help them to choose and administer more targeted, and hence more efficient interventions. Therefore, we collaborated with the administrations of two Swiss cities to develop a framework that explains the process and determinants of behavior change for different types of energy-relevant behaviors. The framework is based on a social-psychological background that combines phase models of behavior change [1] with research on determinants of pro-environmental behavior [2] for different types of pro-environmental behaviors (bike riding; energy-efficient homes; meat consumption; prolonged usage of mobile phones). First, we introduce the psychological background and derive propositions. Second, these propositions are analyzed in an empirical study among the citizens of a Swiss city. Finally, we discuss implications for the design of targeted and effective interventions.

2. PSYCHOLOGICAL BACKGROUND AND PROPOSITIONS

A considerable number of studies in environmental psychology and related disciplines investigate and describe determinants of pro-environmental behavior (for an overview see [2]). There is considerable agreement on the importance of attitudes, norms, emotions, perceived behavior control when predicting pro-environmental behavior [2]. However, generally those previous studies do not account for the dynamic nature of behavior change and disregard the diverging importance of the above-mentioned psychological determinants along the process of behavior change. The present paper addresses this gap in the literature and proposes a more differentiated understanding of pro-environmental behavior, based on the combination of psychological determinants (e.g. attitudes, norms) and phase models of behavior change. These models explain behavior change along a linear process with different phases also in the context of pro-environmental behavior [1]: the predecisional action phase (1), preactional phase (2), actional phase (3), and postactional phase (4). Moreover, they propose that within each stage different psychological determinants predict behavior change [3]. Hence, we derive the following proposition:

> P1: The influence of psychological determinants on pro-environmental behavior varies depending on the target groups' phase of behavior change.

Additionally, the present paper draws on previous research that differentiates between different types of pro-environmental behavior, clustering conservation behavior based on distinct dimensions (e.g. curtailment vs. efficiency; behavioral vs. technical; repeated vs. investment; difficult vs. easy) [4,5].

Consequently, this research suggests that the influence of the psychological determinants depends on the type of pro-environmental behaviors. Therefore, we propose the following relationship:

P2: The influence of psychological determinants on pro-environmental behavior varies depending on the type of pro-environmental behavior.

3. EVIDENCE FROM AN EMPIRICAL STUDY

In order to test these propositions a survey among randomly selected citizens of a medium sized Swiss city was conducted (N = 1798; response rate of 51%). The questionnaire included the following constructs: Social norms, personal norms, anticipated emotions, attitudes, perceived behavior control, behavioral intentions and self-reported environmental behavior. All measures have been used in previous research and have been found to measure the respective constructs reliably [1]. Additionally, we measured an individual’s phase in the behavior change process. All of these constructs were related to the four different types of energy consumption behavior that had been determined as most relevant in collaboration with representatives of the city administrations: (1) bike riding instead of using a car; (2) energy-efficient homes; (2) reduced meat consumption; (4) prolonged usage of electronic devices. Results – based on a multi-nominal logit approach – confirm propositions: First, findings corroborate that the influence of the psychological determinants varies along the process of behavior change. Second, the empirical evidence substantiates that the influence of those determinants depends on the type of pro-environmental behavior.

4. CONCLUSIONS

This study adds to existing research in several ways. First, this approach enhances our understanding for pro-environmental behavior because it combines the dynamic nature of human behavior by accounting for the procedural character of behavior change not only with psychological determinants (e.g. attitudes, norms) and but also with the type of behavior addressed (e.g. bike riding instead of using a car). Second, the empirically verified model of behavior change will provide a heuristic framework that helps to segment the population and to choose appropriate interventions along the process of behavior change. This should allow local authorities to address the population segments with more impactful interventions based on citizens status in a certain behavior change phase and adapted to the type of pro-environmental behavior.

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AN EMPIRICAL STUDY OF THE FACTORS UNDERLYING THE IMPLICIT DISCOUNT RATE: FINDINGS FROM REPRESENTATIVE SURVEYS IN EIGHT EU COUNTRIES

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Keywords: Implicit Discount Rate, Energy efficiency, Adoption, Households

1. INTRODUCTION

Bottom-up energy models often use so-called implicit discount rates (IDRs) to model household investment behaviour in energy efficient technologies (EETs) [1]. Typically, estimating IDRs involves a comparison of initial capital or purchase costs with future operating costs of technologies. Since IDRs are derived from technology adoption behaviour (i.e. IDRs are estimated to be higher when EET adoption is lower), there is a direct link between empirical results obtained on EET adoption and IDRs used in models. In practice, modellers struggle to find adequate proxies for these IDRs. Noting that the factors behind the IDR are typically blurred and fractional, [1][2] provide a comprehensive framework of the underlying factors of the IDR, which includes three broad categories: (i) preferences such as time preferences, risk preferences, reference-dependent preferences such as loss aversion, and pro-environmental preferences; (ii) predictable (ir)rational behaviour, i.e. bounded rationality, rational inattention, and behavioural biases, such as present bias or status quo bias; and (iii) external barriers to energy efficiency such as split incentives, lack of information, or lack of capital. This paper empirically analyses the relations among key factors of the IDR and socio-economic characteristics. The findings can help modellers relate the IDRs to available data on household characteristics such as income or age.

2. METHODS

2.1. Survey

A demographically representative online survey was implemented between July and August 2016 via computer-assisted web interviews among about 15,000 participants from France, Germany, Italy, Poland, Romania, Spain, Sweden, and the United Kingdom. The survey elicited time preferences, risk preferences, and loss aversion via (partly) incentivized multiple price list experiments (MPLEs). Additional questions collected information on socio-demographics and individual attitudes.

2.2. Dependent variables

Based on the framework developed in [1][2], the survey gathered information on factors underlying the IDR (variable used in () and expected effect on IDR based on literature in []): *standard time preferences (standard time discount factor* [-]*), risk preferences (coefficient of risk aversion* [-]*), loss* *aversion (coefficient of loss aversion* [+]*), present bias (present bias discount factor* [-]*), environmental preferences (environmental identity (ID)* [-]*), social norms (scale of social norms* [-]*),* and *access to capital (scale of access to capital* [-]*).*

2.2. Covariates

Covariates included age, gender, education level, and income, whether the respondent had children, lived in a couple, lived in an urban area, and the score on a standard cognitive ability test.

2. RESULTS

Based on individual multivariate analyses for each of the seven dependent variables in each country, Table 1 reports (qualitatively) the effects of age and income on the size of the IDR. Empty cells mean that the p-value of the coefficient exceeded 0.1. Table 1 suggests that higher age is typically associated with a lower IDR and higher income is typically associated with a lower IDR.

Table 1: Overview of findings on the effects of income and age on the size of the IDR

		FR	DE	IT	PL	RO	ES	SE
Standard time discount factor	Age							
	Income	-	+					
Coefficient of risk aversion	Age	+	+					+
	Income	-					-	-
Coefficient of loss aversion	Age							
	Income		-	-	-		-	-
Present bias discount factor	Age			-				
	Income							
Environmental ID	Age	-	-		-	-	-	-
	Income							+
Social norm scale	Age	+	-				-	-
	Income		-	-	-	-	-	
Access to capital scale	Age						-	-
	Income	-	-	-	-	-	-	-

4. CONCLUSIONS

These findings suggest that the IDR should be lower for higher income households, and – unless the effects of risk on technology adoption are very strong – also for older households. For both covariates), these findings are not driven by (time) discounting, but by other factors underlying the IDR such as risk aversion, loss aversion, environmental ID and social norms. These findings can therefore help energy modellers relate the IDRs to available data on household characteristics.

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Families as early adopters of car sharing systems?

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Keywords: car sharing, electric vehicles, user groups, family households, user perceptions

1. INTRODUCTION

The daily mobility requirements are very high for families. This means family households make more trips than households without children, they use cars more often and own more cars on average than other population groups [1]. Moreover, families are less likely to use public transport [2].

Simultaneously, the negative impacts of motorised private transport are becoming ever more apparent including CO_2 emissions, congestion, air and noise pollution and growing competition for limited urban spaces. Sustainable mobility concepts, such as car sharing, can contribute to tackling many of these pressing problems, especially in cities. Car sharing schemes allow individuals access to a car when they need one without having to buy one. Such concepts could also integrate electric vehicles (EVs). EVs can significantly reduce noise, CO_2 and other pollutant emissions.

2. RESEARCH OBJECTIVES

We take an in-depth look at (potential) user groups of new mobility concepts that include electric vehicles, such as car sharing, and especially at the role families play. Due to families' high daily mobility requirements, using these new concepts can be a challenge in terms of transport needs and flexibility.

The paper aims to answer the following research questions: Who is likely to be interested in (electric) car sharing? What are families' demands concerning car sharing?

3. METHODOLOGICAL APPROACH

We draw on quantitative and qualitative data. First, we look at survey data (n=947) from a number of field trials within the pilot regions for electric mobility. All the survey participants used an electric vehicle as part of a car sharing scheme. The mean age was 39 years, 17% of the sample was female, 62% of the respondents hold a university degree.

Second, we draw on interview material with 42 parents representing 22 families. The study area comprises three cities (<100,000 inhabitants) in Germany, where there is a good supply of public transport and car sharing providers. The sample is made up of households with leanings towards sustainable mobility (six families do not own a car) and a high level of education.

4. RESULTS

The quantitative study shows that the average user of electric car sharing systems is similar to

users of EVs [3] and of conventional car sharing [4],[5],[6]. To better describe these users, we applied cluster analyses (hierarchical cluster analysis with the average linkage algorithm, cluster centre analysis using the k-means algorithm) which led to the identification of three groups: "Multimodal car-free young people" (56 percent), "couples and young families with a car" (36 percent) and "older monomodal pedelec users" (8 percent). While the first cluster consists of young car-free persons in small households with a high affinity for sharing, the second cluster comprises (also) families with children. The average age of users in this second cluster is 41 and the rate of car ownership is very high (99 percent). Thus, there are families among the early adopters of new forms of mobility who use electric car sharing in addition to their own car. This raises the following questions: What demands do they have when it comes to the use of these new mobility concepts? Are these new concepts able to meet families' specific daily needs?
The results of the qualitative study reveal that, while all the families are in favour of car sharing, only five families who do not own a car actually use it. Car sharing is mainly used for shopping, i.e. other everyday trips are covered by other modes of transport. However, and in contrast to the stated positive attributes, the actual intention to use car sharing is low among non-users: The reasons most often cited for this are complex logistics (reaching the car-sharing stations with children, organizing child seats) and the perceived inflexibility compared to owning a vehicle. In addition, it is important for some families to always have a vehicle at their disposal, e.g. for emergencies. Accordingly, the families outlined their conditions for using car sharing in the future: A car sharing station very close to home with vehicles always available, even when booked very short-term. The families supported the integration of electric vehicles into car sharing systems and some expressed the intention to use the vehicles in order to experience the technology first-hand. However, some families stated that electric car sharing vehicles would not be suitable for weekend trips due to their limited range.

5. CONCLUSIONS

Families are an important group when it comes to changes in travel mode choices. However, our findings present a mixed picture. While there are families who are open to (electric) car sharing and already use it successfully in their daily lives, for many others it is still psychologically distant and in conflict with their norms and expectations, such as full availability.

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HOW TO ACHIEVE THE SWITCH FROM PRIVATE CAR USE TO SUSTAINABLE TRANSPORT OPTIONS

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1. BACKGROUND

The mobility sector accounts for more than a third (36.4% in 2015) of the total energy consumption of Switzerland and is of major concern due to its reliance on fossil fuel and its emissions (CO_2 and others)[1]. Despite intensified policy efforts, private motorised vehicle use is still on the increase [2]. Within the private mobility context one major issue is the car use for leisure purposes, which substantially exceeds commuting travel [3]. In the political context, e.g. the energy strategy for Switzerland 2050, a substantial reduction of 17 TWh is demanded in the mobility sector [4]. In order to achieve the reduction goals consumption in leisure-related mobility private car use needs to be addressed and directed towards other less fossil-fuel-intensive modes of transport [5].
Sustainable transport research has mainly focused on commuting and mode choice in commuting and holiday transport [6],[7],[8]. There is very little research about leisure travel and mode choice. The reason for this could be that mode choice is very diverse [9]. Most studies, analysing determinants of mode choice, focus on financial or non-financial incentives. One study, investigating reasons for mode choice in commuting and leisure travel, found those reasons differ; for commuting, instrumental aspects (e.g., convenience) were key, for leisure in addition to instrumental aspects, affective aspects (e.g. relaxation, flexibility and no-stress) were important [10]. However, so far it is unclear what instrument (financial or non-financial) is effective under which circumstances in bringing about a sustainable transport transition. Therefore, the goal of this paper is to analyze the impact of different measures (financial and non-financial) on mode choice in leisure travel.

2. METHOD

Data will be collected via an online experiment with a representative Swiss sample (in respect to age, gender and regions (excluding the Italian-speaking part)) of 500 participants. The experiment will be embedded in a panel survey of the Swiss Household Energy Demand Survey due to run on the 15th of April 2018 [11]. Participants are randomly assigned to five types of instruments; two financial (CO2 tax, road pricing) and three non-financial (information on usable-time, health information & social norm,) treatment groups or to a control group. Participants will then be asked about their preferred mode of transport for visiting friends and family for a day receiving two scenarios, one for a short-distance trip (5km) and one for a long-distance trip (100 km). Travel mode options vary according to distance (i.e., short: Bike, Car, Public transport; long: Car, Public transport, Train + Car sharing). In addition, each participant receives follow up questions about wellbeing related aspects. We control for availability of cars, train passes and socio-economic factors.

3. RESULTS AND CONCLUSIONS

Data of the experiment (expected at the end of April), will be analysed with MANOVA and Regression analyses. Results will provide insights into the relative influence of financial and non-financial factors on choice of mode of transport in short and long distances leisure trips. Furthermore, analyses will provide insights into the role of wellbeing-related aspects for such choices. The results and conclusions will be relevant for actors designing and carrying out interventions to stimulate more sustainable travel (e.g., government agencies, NGO).

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DEVELOPING AN AGENT-BASED MODEL TO ASSESS BEHAVIOURAL POLICIES: PERSONAL CARBON TRADING

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1. INTRODUCTION

Because Personal Carbon Trading (PCT) represents a fairly drastic policy option for reducing carbon based energy demand in the household sector, investigation of this option is necessary[i]. Currently empirical evidence about PCT's success is scarce because no real world applications of sufficient size exist. Moreover, only few studies investigate potential household behaviour in a PCT scheme. Basic assumptions of PCT are that households are (per capita) granted a certain amount of CO_2 allowances they may exploit by using carbon based energy at home or for mobility. Alternatively, households may keep their carbon footprint lower than 'allowed', by increasing domestic energy efficiency or by reducing their car use. Households exceeding their cap may be punished by a fee and must buy additional allowances from those modest households. Agent-based modelling and simulation[ii] can be a tool to investigate potential developments in this field, by confronting an artificial agent population representing abstract households with such a scheme. A simple model containing the basic assumptions about PCT and its potential for energy demand reduction may be sufficient, to explore this potential.

2. MODEL BACKGROUND

A PCT scheme aims to reduce carbon footprints of households (HH). The Agent-based model (ABM) addresses the forms in which social structures within a PCT scheme come into view from complex interactions among households, and how those structures and incentives affect and/or limit behaviour. The mechanism is as follows: HH respond to PCT scheme by
1) reducing their carbon footprint (by *sufficiency, curtailment*),
2) installing renewables, refurbishing houses, etc. (invest in *infrastructure*),
3) purchasing energy efficient ("low carbon") appliances (increase *efficiency*) and
4) also buying and/or selling allowances depending on allowance budgeting (*trading*)

[i] *"binding 40% energy efficiency target for 2030"* https://www.eceee.org/all-news/press/press-2017/eceee-welcomes-parliament-support-for-binding-40-energy-efficiency-target-for-2030/
[ii] More information on ABM and the software used here: http://www.sagepub.com/sites/default/files/upm-binaries/17239_Chapter_1.pdf and https://ccl.northwestern.edu/netlogo

On the individual level, agents represent HH members. HH Agents are heterogeneous with respect to: carbon intense lifestyle, income (affluence), tendency towards socio-ecological or economic concerns. In total there is a limited (i.e. 'cap') amount of allowances for CO_2. Monthly allowances are set equal for all agents in the initial allocation and in each year's allocation. However, as indicated in the literature, the amount of allowances may decrease each year (by 1% up to 10%). This indicates that the PCT scheme may only apply for a limited time. An agent's *environment* is composed of other agents of the same type but with different profiles (heterogeneity of the social environment). No direct interaction is assumed, rather indirect contact via an artificial social network and a trading "market" platform for buying/selling allowances. Social comparison is possible via demand/supply allowance ratio: agent *A* realizes that it produces more carbon than 'allowed' and has to buy additional allowances from those who used less than allowed (it may also receive a financial penalty). Agent *B* in contrast, has more allowances than it needs and may sell them (depending on the market price). Moreover, agents perceive their network's agents' behaviour and learn (influencing the decision to sell allowances, for instance). Agents also perceive other agents' effort to reduce their carbon footprint and can compare their own performance with the average in the social network. No purely 'rational' agents are assumed but HH adapt (or not, if affluent enough) their energy consumption (i.e. learn from previous rounds) depending on their tendency for both socio-ecological or economic concerns. If they exceed their allowance, it depends on their tendency towards socio-ecological issues for how they try to lower their energy demand in the next round (month). There will be a certain number of allowances for 'sale' from HH who's actual CO_2 emissions are lower than they're allowed and/or manage to budget efficiently. And there will be some allowances for 'purchase' from HH who need allowances (e.g. because of unwillingness or impossibility to reduce their carbon footprint).
There are different options to calculate the 'market price' of allowances. In this version of the model the price for allowances is calculated according to the simple formula in LeBaron, 2001: $p_{t+1} - p_t = \alpha(D_t - S_t)$[iii].

MODEL DYNAMICS

Agents 'experiment' with their consumption/allowance ratio. This depends on the affluence. If the energy bill is low relative to the income, HH don't need respond to consumption overshoot as long as they can buy allowances on the 'market'. Only if allowances become short and more expensive and a penalty for crossing the limit repeatedly applies, they will need to adapt. The dynamics will show what happens in terms of impacts of different preferences and behavioural observations and suggest what additional policies may apply.
Although currently only preliminary simulation results are available, it appears that agents oriented towards economic benefit ('rational') learn quicker to use PCT for their gain than those with low economic interest. However, even those who respond for socio-ecological reasons apply PCT, because their of investment in options 1 - 4. Further simulations follow.

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CONCEPT ON MODELLING THE ADOPTION OF ENERGY-RELATED TECHNOLOGIES ON THE BASIS OF INVESTMENT DECISIONS OF PRIVATE HOUSEHOLDS AND ORGANIZATIONS IN THE ENERGY INDUSTRY

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Keywords: Investment-decisions, Technology Diffusion, Modelling Framework

1. INTRODUCTION AND MOTIVATION

In order to achieve CO_2-reduction targets, a variety of techno-economic energy system models have been developed, resulting in future technology portfolios. The results of those models can depict a bandwidth of different technologies needed in future. The question arises, how the target systems can be achieved as there is heterogeneity of decision-makers who are responsible for the adoption of energy technologies. As it is well known in psychology and sociology, when taking investment decisions, various non-economic factors, such as values, attitudes and social norms, come into play [1]. Starting from the different decision makers we aim to understand the decision process as well as quantifying the factors and their relative weight to enable the modelling of diffusion. We present first results of a research project in which those factors are analysed. We want to discuss the methods we used to empirically investigate them and the approach we developed to integrate these factors into a modelling framework. The paper will end with a critical reflection.

2. METHODS

(1) A literature review of psychological and sociological theories and empirical studies was undertaken [2] in order to identify key factors, which influence investment decisions of private households and corporate actors (local utilities, large utilities, green electricity providers and energy cooperatives). Two empirical studies were conducted with the focus on private and organizational decision makers regarding their current and future investment behaviour. (2) For *private decision makers,* a two-step procedure was applied to identify the (weighted) factors relevant for investing. For investments in PV-battery systems, 1500 private owners of row house and (semi-) detached houses participated in an online survey. The importance of the factors (a) time of realization, b) investment cost, c) payback time, d) degree of self-sufficiency and e) environmental impact was assessed in a discrete choice experiment (choice-based conjoint, Sawtooth Software) through varying the different levels with real-life value of the factors named above. In addition, a questionnaire comprising socio-demographic variables and internal factors (e.g. attitudes regarding the environment, financial benefits, autarky, technological risk; the subjective and moral norm; perceived behavioural control; user-friendliness), was presented to the

participants. The empirical data of the choice experiment is used to relate future characteristics of technologies to a time-scale and therefore, predict the probability of an investment decision at different points in time. (3) For the analysis of *organizational investment decisions*, business reports were analysed, semi-structured expert interviews were conducted, and an expert workshop was undertaken to finally discuss our empirical findings, which will be complemented by a Delphi workshop. (4) On this empirical basis, a modelling framework is developed to simulate diffusion processes of the technologies.

3. RESULT

For *private investment decisions*, the method of calculating the overall utility on the basis of partial utilities and their weights within different market phases is used. The utilities and their weights are identified within the empirical study. (1) Decision: A discrete choice model is applied to calculate the probability of adoption. (2) Stock calculation: Considering the decommissioning of technologies and the adoption calculations the annual installed capacities will be calculated for Germany. (3) Comparison to target system: The long-term technology stock in 2050, the intermediate in 2040 and 2030 as well as the short-term in 2020 will be compared to a target corridor. (4) Development triggers: If the achieved system has a large deviation to the target corridor, a trigger (e.g. investment grant) can be enabled.
In the case of *organizational investors* following main findings can be drawn: Disregarding small-scale investments in pilot projects made for R&D or publicity purposes, investment decisions in technologies must be profitable. In a second step, the choice of technologies or projects is further influenced by criteria such as the corporate strategy, the (socio-) political context, or the public acceptance of technologies. Different types of actors (eg. large utilities, energy cooperatives) have different threshold values related to profitability and rate non-economic criteria differently.

4. CONCLUSION

Main conclusions are: (1) For private decision makers the investment influencing factors for the adoption of PV-battery systems can be modelled using quantitative empirical data from a discrete choice experiment, cluster the data into reasonable sub-groups and apply the method of a logit model. (2) Due to heterogeneous structures, small sample sizes, changing role models and rather short planning horizons the quantification of investment influencing factors of organizations apart from economic investment benchmarks, is complex. A differentiation between local utilities, regional utilities, large utilities, energy cooperatives and project planner was identified as useful to understand the processes in organizational structures, which serves as a basis for future work.

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UNDERSTANDING THE PRESENCE OF ENERGY EFFICIENCY MEASURES IN THE ENGLISH PRIVATE RENTED SECTOR

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Keywords: Private rented sector, Energy efficiency, Dwellings, Uptake.

1. INTRODUCTION

In order to achieve the UK Government's target of an 80% reduction in emissions by 2050 substantial improvements are needed in the energy efficiency of the existing UK housing stock. The private rented sector (PRS) warrants study as it is the second largest tenure in the UK, accounting for 20% of households [1], and has the lowest levels of energy efficiency measures [2].

The authors consider the uptake of energy efficiency measures to be a socio-technical phenomenon, and that an improvement in our understanding of the uptake of energy efficiency measures in the English PRS requires a broader understanding of landlords' practices. Using Schatzki's social practice theory [3] as a basis for the conceptual framework of the study, the authors investigate this phenomenon with a combination of quantitative and qualitative methods.

This paper presents the quantitative analysis undertaken in phase 1 of the study. Probit models were used by Brechling and Smith [4], Hamilton et al. [5], [6] and Leicester and Stoye [2] to examine the presence of energy efficiency measures in the English housing stock whilst controlling for household, dwelling and geographical characteristics. The authors use a similar approach to provide a detailed picture of the factors associated with the presence of energy efficiency measures within the PRS and extends the model to explore associations between the presence of energy efficiency measures and three proxies for landlords' practices - 1) possession of an Energy Performance Certificate (EPC), 2) tenant satisfaction with repairs and maintenance, and 3) condition of the dwelling in relation to damp and mould growth.

The paper seeks to answer the two following research questions:

1. How does the presence of energy efficiency measures in the PRS relate to household, dwelling and geographical characteristics?
2. How does the presence of energy efficiency measures in the PRS relate to proxies for landlords' practices?

2. DATA & METHODS

This paper uses data from the English Housing Survey [7] a repeated, cross-sectional survey of housing in England that consists of both a household questionnaire and a physical property survey. The stratified random sample includes around 13000 households, of which a subset of 6000 dwellings is surveyed. The paper uses bivariate and multivariate logistic regression to explore the associations between the presence of common energy efficiency measures (cavity wall insulation, loft insulation, double glazing and condensing boilers), household, dwelling and geographical characteristics, and proxies for landlords' practices as mentioned above. Logistic regression is used to generate odds ratios as a means of understanding the association between the presence of energy efficiency measures and other categorical variables, and to calculate whether the odds ratios are statistically significant. The results therefore give a detailed picture of the factors that are associated with the presence of energy efficiency measures within the English PRS.

3. RESULTS

The results show few significant associations between household characteristics and the presence of energy efficiency measures. Dwelling characteristics, in particular dwelling age and to a lesser extent dwelling type, are more strongly associated with the presence of energy efficiency measures. The presence of fabric measures (cavity wall insulation, loft insulation and double glazing) is higher for buildings constructed since 1919 (odds ratio OR from 1.77-6.12; $p<0.05$), with the exception of those buildings constructed in the 1980s, and highest for those built since 1990 (OR from 5.83-25.89; $p<0.001$). The presence of condensing boilers shows a different trend with dwellings constructed since 1990 (odds ratio OR=0.50 [0.33-0.71]; $p<0.01$), and in the 1980s (OR=0.37 [0.22-0.63]; $p<0.001$) having a lower odds of having condensing boilers than those built pre 1919. With respect to dwelling type, converted flats (OR=0.30 [0.15-0.62]; $p<0.01$) and low rise purpose built flats (OR=0.38 [0.22-0.65]; $p<0.001$) are associated with lower levels of loft insulation. Geographical region has a significant effect with the East, London, the South West and the South East having the lowest levels of fabric efficiency measures (OR from 0.15-0.53; $p<0.05$).
Of the variables used as proxies for landlords' practices: lower levels of loft insulation were associated with dwellings where tenants were less satisfied with the repairs and maintenance of their rental property (OR=0.59 [0.45-0.77]; $p<0.001$); damp problems were associated with lower levels of all fabric efficiency measures (OR from 0.39-0.63; $p<0.05$).

4. CONCLUSIONS

The analysis has started to build a detailed picture of the presence of energy efficiency measures within the PRS. It has shown that dwelling characteristics are strongly associated with the presence of energy efficiency measures, whilst household characteristics show few significant associations. The associations vary between energy efficiency measures, highlighting the need to examine energy efficiency measures separately. There is still a need for further investigation, in particular to distinguish between the presence of energy efficiency measures and their uptake. At this stage it is not possible to distinguish between landlords' investment in energy efficiency measures and the condition of the property when it was acquired, however the association between tenant satisfaction with repairs and maintenance and higher levels of loft insulation might indicate that landlords are investing in some of the cheaper energy efficiency measures. The model also requires further refinement to take greater account of the interactions between variables and could be extended to explore trends over time. These results have informed the design of the qualitative method for the next phase. The final phase will be to explore and integrate all quantitative and qualitative data to provide a better understanding of the uptake of energy efficiency measures in the PRS.

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LEARNING WITH STUDENTS ABOUT ENERGY CONSUMPTION BEHAVIORS

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Keywords: Characterization of behaviors; Project based learning; energy demand; behavioral change

1. INTRODUCTION

Energy behaviors are acknowledged as an important element in promoting end-use energy efficiency in the residential sector [1]. However, energy behaviors are still an underexploited resource due to the lack of adequate approaches to address their complexity. The creative combination of different disciplines is required to develop comprehensive approaches to the understanding of energy behaviors and promotion of end-use energy efficiency in more effective interventions [2,3].

This paper presents the ongoing work developed in the framework of a practice based research project involving several higher education institutions in Portugal. The purpose of the project is to induce more efficient energy behaviors using a mobile application. Students with diverse backgrounds are involved from an early stage throughout the entire process, starting with the characterization of end-users' energy behaviors and energy demand, establishing the most effective feedback advices and rewards to induce best practices, and designing the app. It is expected that the problem based learning approach not only promotes energy behavior changes in the app's adopters, but also induce behavioral transformations on the students involved thus spilling over to their family context.

2. DESIGNED GUIDELINES

Using the research team experience in the design of energy efficiency programs such as the Portuguese Efficiency Promotion Plan in electricity Consumption, the project aims to lead students to question, analyze and propose innovative ideas about end-users behaviors and energy efficiency. Courses related to energy efficiency topics taught in the three participant institutions are adapted and their usual assignments directed to use a problem-based learning approach. In task 1 behaviors are characterized, making use of different worldviews by using electrical engineering students, with a more technical focus, and students with other diverse backgrounds (e.g., environmental engineering, accounting, marketing). The combined effort is expected not only to reflect the different worldviews, but also the different contexts, associated to the different territories in which the information gathering process happens. Information will be used to feed inquiries and the mobile application, as a continuous feedback process between the app audience and the technical platform. The outputs of this process will be discussed with students from the different institutions in joint workshops, as well as with the public, through the collaboration with Energy Agencies.

3. CURRENT STATUS OF THE PROJECT

The first activity has been conducted with students of energy management related subjects on electrical engineering and energy and environmental courses (BSc and 1st year MSc), on the three participating institutions, as part of their evaluation assignments. This work will be further developed by 2nd year MSc students which will have the responsibility of adapting the information to the required structured format to feed the database. A significant amount of data was already collected, such as the average consumption of Portuguese households, real case studies to be shown as examples, energy policies, instruments and fiscal incentives to energy efficiency, portfolio of saving opportunities in the residential sector, emergent challenges in the context of smart grids. Another relevant approach, developed by a group of students, was the creation of query diagrams exploring each end-use to raise questions to be asked on the inquiry process.

4. CONCLUSIONS AND FUTURE STEPS

At this time, the second task of the project is still starting, which aims to develop an interactive app that will engage young consumers and provide a two-way communication system on end-users' energy consumption practices. Accordingly, the conclusions of the project are still out of reach. However, its development until this point has already raised important challenges regarding the multidisciplinary research work, and most of all, have been fruitful in terms of motivating students, which, at the end of the day, are themselves energy consumers whose behaviors are being influenced.

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A CLIMATE POLICY GAP: SWEDES ARE WILLING TO PAY MORE FOR THEIR AIR TRAVEL EMISSIONS THAN THEY HAVE TO

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Keywords: WTP, CO2, aviation, conditional cooperation

1. INTRODUCTION

In order to limit global warming to 2°C by the end of this century and potentially even return it to 1.5°C, rapid and deep decarbonisation of various sectors of the economy has to start as soon as possible [1]. Aviation is a sector whose emissions are projected to grow by a factor of seven to ten between 1990 and 2050 [2]. Without policy interventions this development of aviation is not consistent with scenarios limiting global warming to 2°C or less. However, so far few countries have introduced direct taxes or charges on air travel, and the aviation sector even benefits from significant subsidies [3]. A more common way to address CO_2 emissions from air travel seems to be voluntarily offsetting of emissions. Accordingly, various studies have investigated air travellers' willingness to pay (WTP) for such voluntary offsets [4]–[8]. In the context of climate mitigation policy, information about WTP in a voluntary payment context is, however, of limited use. Contingent valuation studies in similar contexts have shown that people may value public goods, such as a stable climate, higher if they are certain that others also contribute, i.e. if their contributions are mandatory [9], [10].

In Sweden, an air ticket tax in the context of climate change mitigation has been proposed by the governing coalition and is subject of fierce debate [11]. In the research informing this discussion, data about the WTP of Swedes for mitigating emissions from flying is limited to people's general WTP for offsets [12]. Moreover, the WTP for climate mitigation in general has been estimated [13], but there is no research on the specific WTP for air travel emissions, and certainly not on WTP in a mandatory setting. Thus, with respect to people's WTP for mitigating CO_2 emissions from air travel in Sweden and the drivers behind it, the existing literature is fragmented and does not provide conclusive answers to at least three questions: What is (approximately) air travellers' WTP for the mitigation of their emission? Is there a difference in WTP for voluntary offsets and mandatory instruments? And what are the factors influencing WTP?

Considering these questions, this paper aims to provide empirical data about how much people value climate change mitigation in a realistic policy context: the pricing of emission from their air travels in and from Sweden. Moreover, policy-relevant factors influencing WTP for climate change mitigation were investigated.

2. RESEARCH DESIGN

The data for this study was collected in a web-based contingent valuation survey (n=500) that was sent to a representative, random sample of 1 507 Swedish adults in January 2017. The contingent valuation of climate change mitigation combined a simple dichotomous choice question about general WTP with an iterative bidding process for those respondents that were willing to pay in principle. All respondents went through the WTP elicitation process repeatedly in order to elicit WTP with different payment vehicles, including a mandatory air ticket surcharge on short-distance flights, the same surcharge on long-distance flights, and voluntary offsetting by purchasing and retiring EU emission allowances. In addition to the elicitation of WTP, the survey asked for sociodemographic data, travel behaviour and some policy preferences in the context of carbon pricing. The econometric analysis of WTP data and its drivers accounted for the two-step decision process, which involved decisions about both general and specific WTP.

3. PRELIMINARY FINDINGS

The preliminary results of the contingent valuation survey and its analysis strongly suggest that more people are generally willing to pay for a mandatory air ticket tax than for voluntary offsetting (75% versus 29%), and that their mean WTP is higher in the air ticket tax framing (41 versus 12 EUR/t CO_2). Mean WTP is particularly high in the low-cost setting associated with short-distance flights (52 EUR/t CO_2) as compared to long-distance flights (31 EUR/t CO_2). Various factors were identified that significantly influenced WTP. The respondents were more likely willing to pay the air ticket tax if they were not frequent flyers, if they had a left political view, if they had a sense of responsibility for their emissions and if they preferred earmarking revenues from the tax for climate change mitigation and sustainable transport projects. These results have various policy implications.

4. POLICY IMPLICATIONS

An air ticket tax appears to be politically feasible in Sweden as a clear majority of people have a positive WTP for such a mandatory instrument. Moreover, an air ticket tax is likely to be more effective than voluntary carbon offsetting in raising revenue that can be used to mitigate (or offset) emissions from air travel, since the specific WTP is higher for a mandatory tax than for offsetting. While the planned Swedish air ticket tax promises to raise significant revenues, its potential steering effect appears to be low for short-distance flights and slightly higher for long-distance flights. Finally, policy consistency regarding the tax base and its revenue use may increase public acceptability of (higher) air ticket taxes. Earmarking revenues is clearly preferred to tax recycling or general budget use.

5. CONCLUSIONS

This study has shown that the results of contingent valuation studies are sensitive to the type of payment vehicle that is used and how it is framed. In this case, a mandatory tax elicited higher WTP than voluntary offsets. In order to increase the usefulness of valuation studies in a policy context, careful choice of payment vehicle is crucial. Ideally, alternative payment vehicles should be tested in the same valuation study, and a comprehensive analysis of the respective drivers behind WTP should be carried out.

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TOWARDS A MORE ENVIRONMENTALLY SUSTAINABLE SOCIETY: PUBLIC PERCEPTIONS OF STRATEGIES TO REALIZE LOW CARBON FUTURES

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Keywords: Embedded emissions, public perceptions, alternative futures, strategies for low-material consumption, resource efficiency

1. INTRODUCTION

A radical step change in the production and consumption of materials and products is needed as part of the transition towards a more sustainable, low-carbon society. Part of this change requires strategic changes to product design, product delivery, and the way resources and services are used, some of which are already gaining popularity (e.g. peer to peer trading). However, little attempt has been made to assess consumer acceptance and adoption of such changes on a larger scale.

This paper reports findings that address this gap, by exploring the social acceptability of a range of different low resource and carbon strategies of consumption. In particular we will identify the perceived risks and benefits that might prove barriers or enablers of change with members of the public using qualitative and quantitative research tools. These results will help us to understand why people support some low carbon strategies over others.

In addition to mapping public perceptions and concerns for drastic low carbon strategies for the first time, we also examine the role of social norms [1, 2] trust [3] and moral considerations [4] in driving support, adoption and concerns of these future strategies.

2. METHODS

After holding expert interviews to identify the business strategies and consumption patterns experts anticipate to be relevant in realizing a low carbon society in the future, we designed six novel scenarios (rethinking business, rethinking ownership, rethinking waste, rethinking community, rethinking lifestyles, rethinking products). Each scenario described a world in which low material strategies (e.g. peer-to-peer sharing, extended warranties, incentivised returns), were the norm by which people lived their lives accordingly (e.g. smaller homes, low product ownership). These scenarios were then discussed in a series of two-day workshops using qualitative deliberative and narrative techniques [5]. In total 51 UK participants took part, split into four groups based on location (Cardiff and Bristol), and socio-economic status (high and low income). The dataset was coded using a grounded analytic approach derived from grounded theory, and then analysed for key considerations and conditions influencing public acceptability [6].

As a next step, an online survey was designed to test results of the qualitative workshops in a wider, nationally representative UK sample (n=1,500). The six low carbon scenarios were embedded as short animated clips presenting the complex content as an immersive vision of the future. Respondents indicated their willingness to embrace each vison of low carbon futures, while also stating perceived benefits and concerns about each strategy. Furthermore, the survey measured respondents' perceived social norms surrounding low carbon futures to identify how individual support is determined by social considerations (injunctive, descriptive norms and collective efficacy). Additionally, trust, general trust and perceived morality of resource efficiency were assessed.

3. RESULTS

Results show that some strategies (such as reduced packaging, repair schemes, extended producer responsibility, and peer-to-peer sharing/trading), were perceived very positively while others (such as product-service systems and carbon taxes), proved much more controversial. Personal preferences for different low-carbon strategies were found to be driven by concerns about trust (general trust and trust in actors), affordability, convenience, expectations about social support (social norms) and moral considerations (fairness and perceived morality of the issue). Despite widespread concerns about some scenarios the analysis also identified that most respondents felt the need for a drastic shift towards a more environmentally-sustainable society, and that most people are generally willing to change their lifestyles and practices to some degree (under consideration of their above mentioned concerns).

4. CONCLUSIONS

Our research provides rare and detailed insight into public perceptions of alternative economic strategies that will need to be considered to realize a sustainable and low carbon society.

The adopted mixed method approach identified that individual support for (radical) low carbon strategies is affected by personal considerations of convenience but also driven by wider social considerations such as social norms and perceived morality of resource efficiency and general trust in others. In this paper we will link our results to the wider issue of shifting towards a low carbon, sustainable society and discuss practical implementation of low-carbon consumption strategies.

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A MODELLING APPROACH FOR THE ADOPTION OF HEATING SYSTEMS BY PRIVATE HOUSEHOLDS IN GERMANY

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Keywords: heating technologies, discrete choice models, consumat approach, consumer behaviour

1. INTRODUCTION

In studies showing possible future energy system scenarios for Germany we see high shares of renewable heating technologies like heat pumps and solar heat for the year 2050 [7], [8]. As today over 50% of all German households use gas as proprietary heating fuel and about 25% use oil [4], [3] it is still a long way to go to reach these scenarios. Especially as the expected usage time of the systems is at least 20 years and the yearly exchange rate is only about 3.27%. Still the transformation of the heating sector is an important part of the German energy transition as around 78% of the end energy demand of households is used for space heating and warm water [2]. The first part of a modelling approach that calculates the decision for different heating systems by private households will be presented in this paper. The aim is to understand the importance of different factors in the decision process better which can help to establish the right measurements to promote renewable heating technologies.

2. DATA AND METHODOLOGY

A questionnaire was conducted in June 2017 in the village of Rainau (Ba-Wü, Germany). The participating households were asked which heating system they would buy and classify the importance of different properties of heating systems: total heating costs, CO_2 emissions, image, innovativeness, grants on investment costs, supply security and ease of handling. Screening of similar studies helped to make this preselection of important factors (e.g. [6], [1]). The model makes use of the consumat approach, which is describing different decision strategies under restricted knowledge of the possible options [5]. This holds true for heating systems as decisions are taken by ordinary persons and often in a rush when the old heating system is broken. The four decision strategies in the approach are shown in Table 1 with their corresponding shares for the households of Rainau.

Table 1: The four decision strategies of the consumat approach

1	I will buy the same system I have today	16.09 %
2	I will buy the system that generates me the highest utility	64.94%
3	I will buy the systems that is recommended to me	8.6%
4	I choose between the recommended and my old system	10.34%

For decision strategy 2 and 4 the highest utility for the consumers is calculated based on utility functions: $U_j = \sum_j^n \beta_j * x_j$, with $1 \dots n$ different heating systems, the properties of the technologies $x_{1 \dots n}$ and the weightings of these properties $\beta_{1 \dots n}$ which are extracted from the questionnaire.

3. RESULTS

The modelling results for two heating systems are shown exemplarily in Figure 1. On the left side the results for oil boilers are shown and on the right side the results for heat pumps. Both results from the model are compared to the historic installation numbers from two different sources [4],[3].

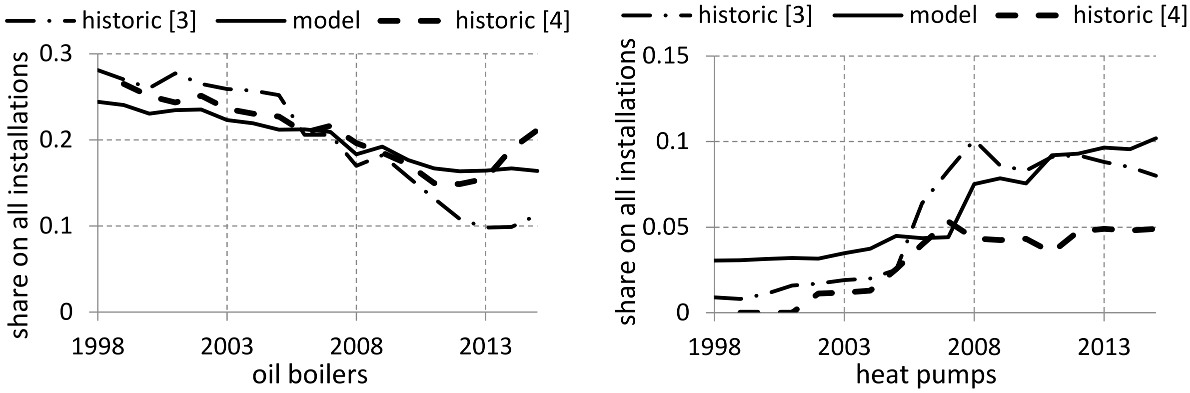

Figure 1: Example for the model results for oil boilers and heat pumps

4. CONCLUSIONS

The model described in this paper can reproduce the installation rates for heating systems in Germany for the time span of 1998 until 2015 quiet well. In a next step the model will be extended with the inclusion of demographic factors to get more accurate results. The extended model will help to understand the importance of different technology- and investor specific determinants for the decision in heating systems and can be used to calculate scenarios for the development of heating systems in the private context in Germany.

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SMALL IS BEAUTIFUL? BEHAVIOURAL CHALLENGES FOR REDUCING BUILDING ENERGY CONSUMPTION BY LIMITING PER CAPITA LIVING SPACE

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Keywords: Energy efficiency, Reduction of Housing Space, Home Owners

1. INTRODUCTION

Per capita living space is a relevant determinant of household energy consumption, because heat demand is directly related to the size of the heated floor space. Its continuous growth dampens the savings achieved by improved building standards and slows down progress in energy conservation. Reducing per capita living space is thus a promising option to cut down energy consumption in the building sector. This does not only imply questions of urban planning, architecture and the real estate market. It also has relevant behavioural dimensions. Designing or choosing one's home is an important life choice related to biographical context, needs, values, goals and aesthetics. In different projects, Oeko-Institut and ISOE have explored target groups, options, potentials, barriers, motivations and instruments for reducing per capita living space. Selected results will be presented in this contribution.

2. SENIOR SINGLE FAMILY HOME OWNERS AS A TARGET GROUP

Per capita living space is unevenly distributed between household types. Larger households tend to have less space per person than smaller ones. One of the groups with especially large floor space is senior citizens, and particularly those living in single family homes. Typically, home owners acquire their dwelling in a stage of household expansion when they have young children, and remain there after their grown-up children left home and / or their spouse died. In 2014, the average per capita living space of people over 65 in single family homes was 70.6 m², with 100 m² for single-person households and 57.5 m² for two-person households (German average being 46.3 m²).[i]

Apart from its impact on energy consumption, which challenges municipalities' climate goals, this situation implies other challenges for local authorities. Regions with decreasing population may face important vacancies in the future. Growing regions, when faced with a demand for housing,

[i] Statistisches Bundesamt [Federal Office of Statistics]: https://www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/EinkommenKonsumLebensbedingungen/Wohnen/Tabellen/TabellenHaushaltsstrukturWohnflaeche.html Unfortunately, no newer data broken down to household types are available.

may feel they need to allocate additional land for building even if large built areas already exist. Consequences include rising infrastructure costs and excessive land use.

For individual home owners, it is often assumed that large living spaces are desirable. However, there may be downsides, too. In addition to high energy cost, large dwellings are costly and difficult to clean and maintain. Furthermore, older family homes are often not adapted to the needs of ageing inhabitants.

3. OPTIONS

Home owners can change their housing situation in different ways. They might either move to a smaller flat or house (with the sub-options of renting, buying, or constructing a new dwelling.) Or they might join a co-housing project, encompassing different age groups, which in many cities emerged as a new and attractive option. They might also divide their house to create a separate flat to be rented or they can construct a new house on the same lot. Each of these options has infrastructural preconditions. A sufficient supply of suitable apartments for senior citizens is a key precondition for moving, but is missing in many German cities and towns. Building design often does not allow to create a separate apartment. Or the size of the plot or legal regulation prevent the construction of a new building.

4. BARRIERS AND MOTIVATIONS

Reduction of living space might be an appealing goal for scientists and environmental experts. For most home owners, however, this goal only appears attractive when it is translated and linked to their personal needs, such as an increase in comfort and independence, less effort or saving of money. But there are strong barriers to be overcome: For a long time, home ownership in Germany was tied to the model of life-long family housing. Housing mobility in higher age groups is rather low. Many home owners stick to their property and want to remain there as long as they can. Knowledge about alternative housing options is lacking and many are unwilling to confront the topic of housing needs in older age at all. There are also practical barriers. For example, many belongings have typically been acquired over the life span which need to be sorted out and cleared. Financial issues are also important, because the price of a new apartment might be higher than the sales revenue from the former house. For many, moving to a multi-family building or renting a part of their own house is seen a loss of autonomy.

In order to address these barriers, a solid knowledge base on the housing situation and needs of senior home-owners is needed. In our contribution we will present findings from an empirical investigation on housing needs and perspectives of elderly home owners, using qualitative and standardized methods. The investigation was carried out in small and middle-sized municipalities in the district of Steinfurt in the North-Western part of Germany. The findings will be used to develop communication campaigns and advisory services in order to support elder home owners with large living space to change their housing situation. The services will be implemented in selected municipalities of the district of Steinfurt.

5 CONCLUSIONS

First results from the qualitative investigation show that a broad variety of situations and needs exists among elderly home owners, some of which actually do correspond to the idea of reducing floor space. Further analyses will be carried out to identify different types or groups. Specifically targeted instruments have to be designed to address the respective needs properly.

SHEDDING LIGHT ON INVOLUNTARY PROSUMERS: IMPLICATIONS OF SHARED RESIDENTIAL SOLAR INSTALLATIONS ON PRO-ENVIRONMENTAL BEHAVIOURS AND ATTITUDES

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Keywords: Solar prosumers, residential PV, pro-environmental behaviour, spill-over-effects, rebound

ABSTRACT

Background: Anthropogenic climate change is a problem for contemporary and future societies. Though the contribution of a single household to this global dilemma is negligible, cumulative effects can be significant if enough households act, for example, by investing in renewable micro-generation, such as photovoltaic systems (PVs) [1]. The latter are an increasingly popular renewable energy-source [2-3], though prevalence of households with PVs is still relatively low [4].
Adopters of residential PV technology (‘solar prosumers’) are often single-family home-owners, affluent, educated and older [5]. Earlier studies identified reasons to invest in solar panels among such autonomous home-owning prosumers, such as financial/economic incentives and environmental concerns [e.g. 6]. Literature on households living in rental apartments and condominiums, however, is scarce, despite the fact that these households too can become solar prosumers if the building-owner(s) decides to invest. Such residents become ‘*unintentional’* prosumers; they do not autonomously decide on investing in solar panels. In contrast to home-owning ‘intentional’ prosumers, these unintentional prosumers often benefit from the reductions in energy expenditures, without the burden of initial investment costs, but also without the initial motivations that led to investment in the first place. They thus form an unbiased group of solar panel owners, in that there is no self-selection at play; any regular tenant, regardless of prior motivations, can become an *unintentional* prosumer. Intentional prosumer or not, without batteries, behaviour change is required to optimize use of solar power; energy consumption should shift to day-time usage. This begs the question: *are unintentional prosumers willing/able to shift their energy-consumption to day time?*
Beyond shifting electricity-consumption to daytime, households with access to solar energy do not need to change much else. Nevertheless, effects on other behaviours, so-called ‘*spill-overs effects’*, may occur, either to the detriment or benefit of the environment. Reduced household electricity bills may ‘backfire’ as increased electricity consumption, a ‘rebound’ effect [7]. Moreover, moral reassurance that one is doing the ‘right’ thing for the environment can result in feeling licensed to perform morally bad (but enjoyable) behaviours, *negative* spill-over effects [8-9]. On the other hand, energy-saving and other pro-environmental behaviours often go hand-in-hand, that is, people who perform one, are more likely to perform similar behaviours [10-11]. This raises the question whether *becoming a prosumer has spill-over effects on other pro-environmental behaviours.*
Aim: The aim of this study is to learn whether unintentional prosumers 1) change their electricity-use pattern when they become aware of their prosumer-state, and are informed on how to make best use of solar-generated electricity and 2) whether and how this affects how they perform, and feel motivated to perform, other pro-environmental behaviours not directly related to their use of electricity.
Methods: We studied a newly built (2016) multi-dwelling building with PVs, comprising of 54 households, situated in Uppsala, Sweden. The fact that the building would have PVs on the roof was not actively communicated to the households before they moved in, nor immediately after. Using quarterly information bulletins, households were informed about their joint PV-ownership and how to

make use of this solar energy by shifting certain household chores to day-time with built-in timers on household appliances. Negative myths on solar electricity and general electricity-reduction tips were addressed, and the second bulletin came with two appliance-magnets explaining how the timer functions. A survey was distributed before (*N*=32) and after (*N*=33) the intervention, gathering data on demographics, electricity-use practices and motivations towards other pro-environmental behaviours. Households' electricity-consumption was collected one year before and during the study. Based on the pre-study data, we built a multivariate time-series model with household-specific parameters using a dynamic structural equation modelling framework (DSEM) [19], thus clustering households with comparable electricity use patterns. Three clusters were identified and randomly assigned to three separate groups that received the same information bulletins but with a time-lag of three weeks. In this way, the three groups (each 18 households) acted as control groups for each other.
Results: Analyses of electricity consumption data suggest a (not significant) increase in the ratio of electricity used per household during day-time. More strikingly, energy consumption (in daily kWh) increased over the intervention period, that is to say, households increased their energy consumption after the intervention. The size of this increase is about 63 Wh per household per day, or 23 kWh per household per year. Counter to this finding are the survey results, where data show an increase in self-reported shifting of electricity use to daytime, as well as in intention to do so in the future, and a moral sense of obligation to do so. Household means in self-reported behaviour, intentions or attitudes concerning the other behaviours did not differ over time.
Conclusion: Households reported stronger feelings of moral responsibility-, intentions to and self-reported behaviour of a shift in electricity consumption to day-time after being informed about their home's PVs. None of the other behaviours' antecedents changed over the study period. However, the self-reported changes did not correspond to the aggregate meter data, which did not show an increase in ratio of electricity used during day-time. This could be explained by the meter data being too noisy to allow detection of small changes in electricity-during-day-time ratio. A larger sample, continuous control group, and more detailed analysis of meter-changes among those households claiming to engage in electricity shifting could shed light on this matter. Alternatively, the lack of consistency between self-report and actual meter data could lie in the fact that respondents misreported (consciously or not) their behaviour change. Rebound or negative spill-over effects may have occurred if respondents felt they changed their behaviour for the better, while unconsciously increasing their consumption compared to the baseline. Follow-up studies in the same, as well as other buildings will enable confirmation and more detailed analyses of the results obtained here.

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THE COMMON SENSE OF ENERGY TRANSITION

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Keywords: social action, energy transition, discourse analysis, text corpus, acceptance

1. INTRODUCTION

In social science, behavior is understood as social action, which in turn is understood as meaningful and as a practice of sense-making [1]. In this framework, linguistic actions ('speech acts', [2]) are particularly important, since they shape, impart, and organize structures of interpersonal meaning and procedures of problem-solving [3] [4]. The notion of *discourse* describes the collective linguistic behavior that give rise to networks of interpersonal meaning as well as the patterns of language use that produce, reproduce, and transform such networks [5]. Since Foucault [6], the conditions, dynamics, and regularities of discourse have been investigated under the banner of *discourse studies* and/or *discourse analysis* [7]. This strand of scholarship has also proven fruitful for transdisciplinary research on energy transition [8] [9] [10] [11].

2. THE ENERGY DISCOURSES PROJECT

Our contribution is grounded in a research project that applies the framework and previous insights of discourse studies to the commitment to energy transition proposed by the Swiss government with its so-called *Energiestrategie 2050* and confirmed in a recent popular vote [12]. The project investigates the discursive genealogy, preconditions, and dynamics of this political agenda since its launch in 2011. In doing so, it reveals some of the fundamental determinants of pertinent behaviour related to end-use energy efficiency and sufficiency as well as to the adoption of low-carbon technologies.

The project began by modeling Swiss energy discourses among diverse actors at various levels of public administration, civil society, and the media. To do so, the project draws on the *Swiss-AL* text corpus (*Swiss Applied Linguistics*), which contains over one billion words from 3.7 million texts published on more than 300 Swiss websites (i.e. those with a .ch URL). The project corpus emulates the multilingual nature of energy discourses in this federalist and multicultural country.

The project is currently simulating diverse formations and dynamic developments of energy discourses within this model. The analyses show how linguistic patterns (such as the frequent use of individual words to refer to diverse conceptualizations of 'energy') shape public communication on the topic and thus the possibilities and restrictions of democratic dialogue and of technical as well as economic innovation. There can be no understanding and thus no acceptance of new regulations and new technologies without a *common sense* expressed and argued by linguistic means [5] [13] [14] [15].

Finally, the project team is mapping pertinent phenomena with the objective of knowledge transfer to actors involved in political and entrepreneurial practice. The mapping can illustrate, for example, how specific actors and actor groups are favoring specific thematic aspects of the official energy policy (i.e. *Energiestrategie 2050*). By doing so, the project allows 'discourse controversies' and 'discourse coalitions' to be traced and analyzed in more detail and consequently collective communicative practices of the so-called 'politics of discourse' [13]. In the wake of a 'discourse controversy', political claims are formulated and made editable in diverse agonal and mediated settings [16]. In contrast, a 'discourse coalition' legitimizes specific claims and links them with familiar claims so they can penetrate into institutional procedures [17].

Preliminary results of the project show, for example, that 'energy discourses' are not among the most widely disseminated ones in the Swiss public sphere. However, they gain prominence depending on specific events (such as the Fukushima disaster) or on direct democratic procedures (as the several public initiatives on the topic in the last few years in Switzerland).

3. TRANSDISCIPLINARY PERSPECTIVES

Discourse analysis contributes to the solution of typical problems that actors encounter in the 'daily business' of pluralistic and mediatized political communication and knowledge transfer concerning energy transition [18]. We argue that multilingual and multilateral communication on energy policy transition and the analysis of it are not only strategic imperatives but also important resources for the improvement and refinement of all activities aimed at the acceptance of transformation and innovation [12] [14].

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TARGET GROUP SEGEMENTATION FOR RETROFITTING – AN ACTION RESEARCH APPROACH

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Keywords: target group segmentation, energy efficiency, buildings, action research, retrofitting behaviour

Heating is responsible for a substantial share of primary energy consumption and still strongly relies on fossil fuels. Therefore, the building sector has become target of various policies – be it to increase energy efficiency in existing buildings as well as in the construction of new buildings, but also to increase the retrofitting rate. Cities are considered to be at the forefront of innovations in buildings' energy efficiency and there are several international initiatives to support cities in becoming more energy efficient, sufficient, and self-reliant. But still, energy efficiency in buildings lags behind its potential. With respect to retrofitting, research identifies many barriers and highlights the importance of combining financial incentives with information measures to increase the retrofitting rate. Several studies argue that target group segmentation is essential in order to reach owners of buildings and to encourage them to consider retrofitting (e.g. Haines/Mitchell 2014; Pettifor et al. 2015).

Our paper exemplifies the cluster approach: a specific target group segmentation approach developed in an energy research program of the city of Zurich in Switzerland, which is funding applied research since 2012. Based on the analysis of statistical data on the city's building infrastructure, 27 different clusters of building were identified, using three structuration principles: building type, legal ownership, spacial relatedness. The clusters were then prioritized according to six criteria: energy reference area, share of fossil-heated energy reference area, barriers for retrofitting, geographical location (e.g. proximity to remote heating), number of owners per building, and multiplication potential. Out of the 27 clusters, 4 pilot clusters were selected for action research. Based on psychological considerations (e.g. referring to Foppa, 1987), the aim of the cluster projects was to empower the respective target groups by providing "impulses" in workshops and enabling peer-to-peer learning. Each pilot project was accompanied by an evaluation research. Synthesising the lessons learnt of those 4 cluster projects, our paper presents an ideal type of a cluster approach which aims at enhancing the capabilities to conduct retrofitting measures of a specific target group.

The cluster approach consists of 5 steps: analysis of the building infrastructure, analysis of characteristics of the building owners, decision on the intervention approach, implementation, and follow-up. It is based on several learnings from the pilot projects: 1) After the first target group segmentation based on "building-related" criteria available from municipal statistics (secondary data), the formed target groups still resulted to be heterogeneous with respect to more subjective or "owner-related" criteria. Thus, an additional step – the analysis of the characteristics of building owners - is necessary in which additional information on the target group is collected (primary data). 2) The efficiency of the cluster approach depends on whether one can identify common interests in knowledge transfer in the target group: common interest emerges when owners experience the same pressure for retrofitting (e.g. dismantling of gas lines), or similar barriers of retrofitting (e.g. monument conservation) or similar interests in technological knowledge transfer (e.g. life cycle cost calculation). For that reason, the third step of the cluster approach refers to the decision about the type of intervention: impulse-workshops (aiming at peer-to-peer learning) in case of common interests in knowledge transfer or individual consultancy in case of individual/specific interests. 3) A comparison of the cluster approach with similar approaches in Germany made evident that more participation possibilities enhances the effectiveness of the cluster approach. For that reason, the implementation step incorporates many interactive elements. Furthermore, the content of the knowledge transfer is elaborated in an iterative process. 4) Effects of the cluster projects are hard to measure in material terms and evolve slowly. For that reason, the fifth step focuses on the continuation of the empowerment of the target group after the intervention. To sum up, the lessons learnt of the pilot projects lead to additional process steps, which allow for more participation opportunities for the target groups and a more flexible, iterative process of content development of the knowledge transfer provided during and after the implementation.

In the pilot projects, the cluster approach demonstrated high quality in output and effectiveness on different levels. Accompanying evaluations of the pilot projects collected data by participant observations during the launch events and workshops (16), interviews with the participants (35) and non-participants (20), as well as interviews and informal exchange with the project team and representatives of the city. In addition, documents of the project team (e.g. concepts) were analysed in order to allow for target-actual comparison. Moreover, the cluster approach was compared to similar approaches in Germany. The evaluations confirm a high quality of the implementation process in the pilot projects. The cluster approach covers several dimensions of successful interventions identified elsewhere (see Flury-Kleuber/Gutscher 2001): In the workshops, statements about reality were made (e.g. referring to CO2-emissions, new technologies), actions were requested by representatives of the municipality (e.g. referring to 2000watt society), model behaviour was presented (e.g. sustainable building owner), and site visits shaped the sphere of experience. With respect to effectiveness of the cluster approach, the evaluations of the pilot projects identified satisfaction, change in attitude as well as change in knowledge and competencies amongst the participants. Change in behaviour could be identified with respect to the elaboration of sustainability strategies. A behaviour change with respect to actual retrofitting could not be captured in the short-term, but a survey amongst the participants of the pilot projects is previewed for 2019. In other words, the cluster approach promises high satisfaction and change in attitudes and planning behaviour of the participants, but it is difficult to quantify the effects in terms of CO2 emission reductions. Finally yet importantly, the cluster approach led to more information exchange between the different departments of the municipal administration involved in retrofitting issues.

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ENERGY POVERTY AND VULNERABLE GROUPS: A CONTRIBUTION ON THE RELATIONSHIP BETWEEN ENERGY POVERTY AND INCOME POVERTY, AS WELL AS ON THE SOCIAL AND ECONOMIC CONSEQUENCES OF ENERGY RETROFITS

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Keywords: energy poverty, income poverty, vulnerable groups, social and economic consequences of energy retrofits for vulnerable groups, exclusion

1. INTRODUCTION

The University of Applied Sciences ZHAW is leading in support of the federal office for housing (BWO) the research project "**energy transition and exclusion: a contribution on the relationship between energy poverty and income poverty, as well as on the social and economic consequences of energy retrofits (2017-2018)**." The project aims to demonstrate the understanding and visualization of the social and economic effects of the energy transition on vulnerable groups from the specific perspective of the discipline of social work, and to research the effects of energy retrofits on social structures. To which extent an energy-deprived living space can become a poverty trap or whether increased rents resulting from energy retrofits can force vulnerable groups to move are some of the projects main questions.

2. GENERAL SPECIFICATIONS

The Swiss energy transition entails reallocation and redistribution of costs in mobility and housing, as well as subsidies for certain energy sources. In current discussions, little attention has yet been paid to how this affects vulnerable groups. Households account for a significant portion of the energy consumption in Switzerland. Accordingly, various measures from the Energy Strategy 2050 aim to improve households' energy efficiency and to reduce energy consumption in the buildings sector. The practice of modernising old houses every few years is one of the most widespread forms of building renovation [1]. For vulnerable groups, partial and complete renovations represent a major challenge, as the renovated flat's increased rent often exceeds the household budget. The extent to which inappropriate housing quality can become a poverty trap and the extent to which increased rents force vulnerable groups to relocate are issues that have only been on the sidelines of empirical, political and social discussions to date. However, research projects from Germany on the displacement of existing tenants as a result of energy-oriented modernisation confirm that this residential displacement affects vulnerable groups in particular, such as solo parents, elderly people, recipients of Hartz IV unemployment benefit and students living in shared flats [2]. Also in Switzerland, the shortage of affordable housing has become more pronounced in almost all cities. More and more people, especially in the lower income brackets, are having difficulty finding a flat with an appropriate rent burden. Demolition, new construction and comprehensive renovations are also being used here as strategies for lifting housing into a higher market segment [3]. The displacement of economically weak households has consequences for the social mix in neighbourhoods and facilitates trends of segregation. When faced with rising rents or excessive bills for heating and ancillary costs, vulnerable groups have to make do without various other bare necessities in order to make ends meet. Households characterised by a combination of low income, limited energy efficiency and high energy costs are considered energy-poor households and are subjected to strain in numerous situations.

3. METHOD AND CONCLUSIONS

Based on fundamental data research the project team focusses firstly on the relationship between income poverty and energy poverty. In a second step we analyze the ways in which vulnerable groups react to increased rents resulting from energy retrofits as well as the coping strategies they choose for reduction of energy costs. Therefore interviews with affected persons, potentially including observations at their homes and expert interviews with professionals, also in reference to example cases will be conduct. On the basis of the extended-cases research method [4], the orientation towards individual cases makes it possible to study “the development of social conflicts, the negotiation of individual interests, the interpretation and circumvention of rules, and the emergence and collapse of social relationships” (ibid.: 144). Even though the project will only end by October 2018 the team will be able to answer the following main questions at the Behave conference:

- What is the relationship between income poverty and energy poverty?
- Which coping strategies and energy practices do vulnerable groups adopt in order to contain and meet energy costs?
- How do energy-oriented flat renovations and the resulting rent increases affect vulnerable groups?
- What are the current mentoring / counseling services for vulnerable groups when it comes to energy poverty or the economic or social consequences of energy retrofits?

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Energy Efficiency of Refrigerators in Germany – The Role of Purchase Behaviour

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Keywords: energy end-use efficiency, appliances, market transformation, top runner, refrigerator

1. INTRODUCTION

A refrigerator can be found in more than 99 % of the approx. 40 million households in Germany. They are connected to the grid 24/7 and consume electricity all day long. That is why it is essential to have a closer look at the factors that influence the energy consumption. In this paper, the question will be answered whether the average energy consumption of new refrigerators in Germany increased or decreased between 2005 and 2015. The effects of policy instruments (like the energy label) and purchase decisions (like the number and size of the product) will be analysed. All figures and numbers in this article are based on data from GfK. They were analysed within the National Top-Runner-Initiative, which was launched in 2016 by the German Federal Ministry of Economic Affairs and Energy. [1]

2. ENERGY CONSUMPTION OF REFRIGERATORS IN GERMANY

Refrigerators are on the political agenda for years. The first product group for which an EU energy label was introduced in 1994 were refrigerators. MEPS followed in 1999 and the energy classes D, E and F were banned from the market. Due to the rapid market development towards increasingly energy-efficient appliances, the minimum standards were tightened again in 2009 and 2012. Since than, A labelled products are no longer allowed to be sold on the market. Today, an average fridge in Germany is around 70 % more energy efficient than a fridge from 2005. The following figure illustrates this development. In 2005 the annual energy consumption of an average fridge was about 240 kWh. In 2015, an average fridge only used 180 kWh of energy per year [2].

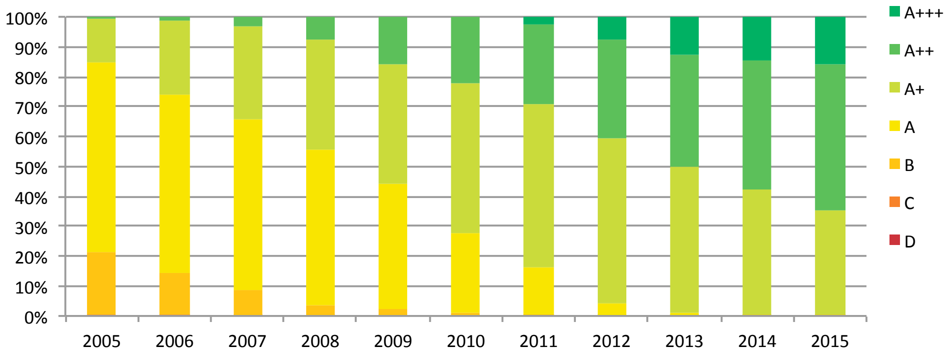

Figure 1: Distribution of energy classes of refrigerators between 2005 and 2015 in Germany

3. THE IMPACT OF PURCHASE BEHAVIOUR

Though the policy has triggered the development towards more efficient products, the saving potential of refrigerators is still huge. One reason for the untapped potential lies in the user behaviour but also in the purchase behaviour. As illustrated in the figure above, top-labelled products are only purchased by 16 % of the German population. In 2015, every second consumer purchased an A++ product and every third consumer purchased an A+ product - the product group with the highest energy consumption. Furthermore, the number of products sold is constantly increasing. A refrigerator can be found in more than 99 % of German households and some households even have two or more appliances. In 2015, there had been 123 refrigerators per 100 households. In comparison, in 2003, there had been only 115 appliances per 100 households [3]. While almost 2.4 million refrigerators were sold in 2005, this figure had risen to over 3.2 million units in 2015 - an increase of over 30 % [2].
The size of the appliances has also increased between 2005 and 2015. In 2005, an average refrigerator had an average volume of 168 litres. In 2015, the number increased to 179 litres. In particular, the proportion of large appliances with a volume of more than 300 litres is increasing. In 2005, these large refrigerators accounted for only 8 % of the market. Ten years later, in 2015, these refrigerators already had a market share of 22 % [2].

4. WHAT DOES THIS MEAN?

Although refrigerators are becoming increasingly energy-efficient, the total energy consumption was only slightly reduced due to the increased number of refrigerators sold. In 2005, the total energy consumption of all refrigerators sold on the German market added up to 600 GWh per year. Ten years later, the energy consumption had been reduced to only 575 GWh. Thus, the energy label and other policy instruments have indeed caused a reduced energy consumption of new refrigerators. However, the energy consumption is still very high due to the increasing number of appliances, larger sizes and additional features.
The figures show that there is still a lot of work to do to reduce the energy consumption in such a way that refrigerators can make a significant contribution to achieving climate goals.
For this purpose several barriers have to be addressed. First, the top-labelled products are still too expensive. In 2015, the purchase price of an average A+++ refrigerator was three times higher than for an A+ refrigerator. Second, there exists a lack of information amongst consumers about the right size and the user behaviour (how to set the right temperature level etc.).
Therefore the National Top-Runner-Initiative developed different tools, such as various videos, quizzes and haptic materials to spread the information. In addition there is a product finder, which helps consumers to find the adequate energy efficient products, which satisfy their needs. Furthermore an online label pilot was developed to use the EU Energy Label as guidance for the appliance purchase. To complete the mix of tools, the sales advisory service of retailers is tackled through education material both via the allocation of slides for physical training and an e-learning tool for salesmen [1].

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HOW TO IMPROVE ENERGY BILLING INFORMATION TO INDUCE ENERGY SAVINGS? INSIGHTS FROM SWITZERLAND

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Keywords: Demand side information, energy feedback, energy consumption, energy billing

1. INTRODUCTION

Many industrialised countries including Switzerland have set ambitious energy reduction goals in response to challenges imposed by climate change. Thereby, private households play an important role, since they are cross-nationally responsible for around 30% of the total energy consumption [1]. Energy feedback has been found to be an effective instrument for motivating households to reduce their energy consumption by up to 20% [2]–[6]. An important branch of this research deals with energy bills as a most widespread feedback medium [7]–[13]. However, since the scope for motivating households to change their energy consumption through informative billing is dependent on national legislation and technology level, it is important to conduct country-specific analyses in order to develop tailored recommendations. Against this background, the potential of low cost, quickly realisable measures to improve information on energy bills in order to motivate households to reduce their energy consumption has been assessed for the Swiss context. As an outlook, some ideas of what the trends of digitalization and market liberalization might imply for demand-side information (DSI) measures in general and energy billing in particular will be discussed.

2. METHODOLOGY

The analysis was based on: (1) literature review, (2) online survey of 54 Swiss utilities, (3) content analysis of exemplary bills of 91 Swiss and 175 foreign utilities from 25 different countries, (4) content analysis of websites of 309 Swiss and 200 foreign utilities from 15 different countries and (5) survey of 400 German-speaking, 426 French-speaking and 1520 Italian-speaking utility customers, exploring in particular their satisfaction with current energy billing and assessment of the preliminary proposals for improved billing developed within the project.

3. PRELIMINARY RESULTS AND CONCLUSIONS

Literature review reveals that effective energy feedback including billing: (1) is frequent, (2) involves comparisons (with past consumption, reference group, goals), (3) is possibly provided in interactive, computerized form, (4) involves environmental impact of own consumption (especially for certain target groups), (5) is as specific as possible (consumption per device or activity), (6) is intuitively/easily comprehensible (graphs rather than tables and numbers) [14]. However, our survey of Swiss utilities shows that current DSI landscape in Switzerland is marked by: (1) low incidence of remote readout implying low billing frequency (2) paper bills as dominant billing practice, (3) comparisons only with regard to own historical consumption, (4) rare deployment of graphs for presenting data. Analysis of the DSI practices on the international level shows a slightly larger diversity of approaches especially regarding appealing designs. Based on those international best practices as well as on examples from Swiss pioneer utilities, five design proposals to improve billing effectiveness were developed, which will *be presented at the conference*. The focus thereby is on short term, low cost solutions, easily deployable on energy bills as a prevalent energy feedback medium in Switzerland. Our survey of utility customers suggests that Swiss households show interest in receiving evaluative judgment of their own consumption presented in a visually appealing manner, including the information on whether and by how far they overshoot or fail a reference level of consumption.

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'The third success factor': Understanding (non)constructive behaviour and (non)helpful organizational processes of renovation projects in the built environment that have highly ambitious energy goals (3SFO).

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Keywords: Organizational behaviour; Organizational change processes; Renovation of housing stock; Knowledge and Capacity building

TOPIC

Renovation projects with highly ambitious energy goals have a larger success chance when productive behaviours are in place as well as supportive organizational processes. ECN part of TNO and partners applied behavioural and organizational change theories towards behaviours and processes displayed in selected case studies to further increase the understanding of these behaviours and processes. We argue this is needed to help professionals working in this field to act on these.

ABSTRACT

Besides acquiring knowledge about technical and financial aspects of renovations with highly ambitious energy goals (towards energy neutral or zero energy) in the built environment, it has been acknowledged by 'front running' experts (housing associations; construction experts; consultants a.o.) that one also needs to understand (non)productive organizational behaviours and organizational processes to realize these ambitious goals. This is needed to successfully deal with the uncertainties, new roles and new responsibilities that exist in and characterize these projects.

ECN part of TNO and partners analysed the behaviours and organizational processes displayed in three selected Dutch case studies mainly. The consortium interviewed the professionals of the parties involved and collected relevant materials that were used in these projects. To gain a better understanding they applied behavioural and organizational change theories towards the behaviours and processes displayed in these projects. One of the key findings is that many (non)productive behaviours and processes are related to mutual trust and dealing with resistance. The main goal was to show professionals the driving factors behind typical behaviours and organizational decisions as well as help them act on these. The research led to valuable insights that were new to many of the professionals addressed. The consortium developed a Masterclass and Training 'dealing with resistance' based on the findings as well as short videos with learnings. These results have all been published early 2018.

The consortium included three well-known research centres in the Netherlands (ECN part of TNO; Nyenrode Business University; Technical University of Delft) with expertise in energy efficiency, behavioural science and organizational change processes. In addition, a building construction firm (BAM) acted as partner, as they have led and still lead several renovation projects in the Netherlands. By using this approach we aimed to secure a link towards the daily business of the professionals addressed.

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An empirical analysis of energy saving measures from a household perspective

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Keywords: Household behavior; Energy saving measures; Adoption of technology; Multi-country analysis

1. INTRODUCTION

Understanding household behavior is a prerequisite for understanding how to motivate or encourage pro-environmental behaviour [1-3]. For the majority of the time, energy use of households is invisible and our energy consuming behavior is mainly based on habits and routines. For example, we leave our thermostat on or leave the television on standby when nobody is home without having to think where the energy comes from or what the environmental consequences are. This behavior is formed by the characteristics of the building and the energy using appliances, but more importantly because they are influenced by a range of internal and external factors, such as our personal characteristics, values and attitudes, behavior of friends and family, and various economic incentives [1, 4-7]. Many studies have focused on social or psychological factors related to energy saving behavior, however, little is known about the effects of these and other characteristics on the success of adopting these measures.

A relevant question, therefore, is why do households consume their energy in the ways that they do and what factors shape and constrain their choices and actions? To answer this question, it is necessary to open the black box of households behaviorism, and to analyze in a detailed manner why and when households behave in a certain (pro-environmental or a prosocial) way and how more sustainable behavior can be motivated or encouraged. Such analysis should allow us to pinpoint key determinants that block or induce their pro-environmental behavior. Insights in these determinates is necessary to design policy arrangements that can efficiently deal with these blocking or inducement determinants, in order to speed up the adoption process of this pro-environmental behavior.

2. RESEARCH METHOD

For this study, we have data collected via an online questionnaire which took place in May 2016 in the Netherlands, Germany, Belgium, and China (Beijing and Changchun) for a sample of 400 households in each country.

The majority of the questions were multiple choice questions with a few open questions. The questionnaire consists of (1) economic variables: private monthly income, electricity expenditures; (2) demographic variable: age, sex, educational level of the respondent, family size; (3) environmental concerns; and (4) energy saving questions: which reduction options taken/ intend to take, barriers and motivations for this action. Regarding the latter, respondents were asked a series of questions about their own energy efficiency and energy saving behaviour.

Descriptive analyses were conducted to analyze which determinants influence household preference for energy saving measures, e.g. motives behind their behavior. In this study we used an indicator-based approach. These respondents were provided with a questionnaire with different items, these items were indicators for analyzing the adoption process of energy saving measures. To compare the differences between a rented house and a property, we used binary logistic regression analysis and ordinal logistic regression analysis to determine the predicting factors for adoption or not.

3. RESEARCH FINDINGS AND CONCLUSIONS

The first findings of this study show that (1) behavioural energy saving measures are more acceptable than technical ones. (2) The adoption of energy savings measures at home is more likely than on the road. (3) There is a relatively small market for technical energy measures, especially through the initial investment and the low return on investment. (4) Environmental aspects seem to be more important for relatively expensive technical energy measures. (5) The reason for taking technological energy measures is rather to be found in differences among socio-demographic background than in environmental concerns. (6) Comfort, at home and on the road is an important explanatory variable that many respondents used to justify not implementing energy savings measures and should be investigated in further research.

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ENERGY EFFICIENT SOLUTIONS FOR SMART CITIES

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Keywords: Energy Efficiency, Smart City, ICT

1. INTRODUCTION

Lately, cities have become the key place for new technologies development and the main driver of changes in the world. The concept of smart cities has become very popular today to increase energy efficiency and sufficiency at urban level. The term "smart" includes amongst others the use of mostly ICT-based technologies to address the challenges of sustainable urban development (e.g. excessive congestion, lack of free parking spaces, inefficient energy use or waste disposal, etc.). Within this concept, the approach of smart energy city appeared [1] especially to optimize urban energy systems through ICT technologies. To understand the needs for energy efficient solutions in smart cities we study first the world experiences. Based on world best practices we develop then a cross-cultural approach to smart energy city in Russia and Switzerland as part of a bilateral research program. For this purpose, we identify and compare energy efficient solutions used by both countries.

2. WORLD EXPERIENCES

This section presents an overview of best practices of energy solutions for smart city development.
For example, in Tokyo energy efficiency is one of the main principals of urban planning. The activities of Tokyo Smart City Development include [2]:

- Smart energy saving that makes maximum use of energy saving technologies and knowhow
- Informing the public about ways of energy saving
- Expansion of use of renewable energy
- Optimal control of urban energy supply and demand via smart energy management
- Formation of monitoring bodies within large urban areas to control energy efficiency

Shanghai actively develops smart grid projects considering new energy vehicles, renewable power and fuels, energy-efficient buildings saving up to 30% of energy, etc. [3]
In Barcelona two of ten smart city programs are implemented in the field of energy [4]:

- Smart light — more than 1100 streetlights with LED lamps and automatically adjustable brightness (depending on the presence of pedestrians).
- Energy self-sufficiency — two tools for general public: the Map of the City's Energy Resources and Virtual Energy Adviser.

Charlotte in 2011 launched a large-scale "Envision Charlotte" partnership program, focused on energy efficiency to contribute economic growth and sustainable development [5]. The main objective of the program was to reduce electricity costs by 20% in commercial & city administration buildings.
The study of world experiences confirmed that a reduction of energy consumption is of great importance for many smart cities.

3. CROSS-CULTURAL COMPARISON BETWEEN RUSSIA AND SWITZERLAND

For Russia, energy efficient solutions (including ICT implementation in energy networks) are the main part of a smart city concept. A case-study in Moscow revealed that energy efficiency is one of the priorities for smart city development The city promotes innovative clusters consolidating different stakeholders actions for energy saving technologies development. In addition, to cultivate a new way of rational energy consumption behavior the system of smart housing and utilities has been introduced. The energy saving issue is also one of the main drivers of smart city development in Kazan. It supports the development of energy efficient solutions such as smart grids and smart meters, intellectual streetlights, renewables, building construction receiving energy efficient certificates.

In Switzerland, the 2000 Watt society is on top of the agenda as a vision enabling the implementation of best practices in sustainable building design, construction and operation [6]. Promoted by Smart City Switzerland, a process was initiated 2013 in the City of Winterthur bringing all relevant stakeholders (from the local administration, energy supplier, local companies, NGO and universities) together in order to identify potential areas of application with the aim of reducing energy consumption and CO_2 emissions. The city carried out pilot projects to develop guidelines for smart area development [7], a socio-economic analysis of smart meter data to optimize electricity consumption [8], a mobile app to encourage energy saving with gamification elements [9], as well as a building specific energy database to support the achievement of the goals of the 2000 Watt society.

Comparing Russia and Switzerland allows to identify solutions useful for cross-cultural approach. Firstly, energy projects should be elaborated through close cooperation of different stakeholders. Joint actions help to develop guidelines and standards for smart energy development. Furthermore, to optimize electricity consumption smart meters and smart grids, different mobile and gamification applications are useful. In addition, an important element of smart city is renewable energy solutions.

4. CONCLUSIONS

All over the world, smart city initiatives strive for better energy usage. Therefore, the implementation of new technologies changes cities life and appearance. The results of the study show that unified cross-cultural approach is of great use for the development of smart energy city. Mutual elaboration of new solutions and exchange of experiences improve energy efficiency in cities. Need for further research is quantitative assessment of smart cities technologies influencing people behavior in order to scale up the most promising solutions for energy efficiency and sufficiency.

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ENERGY EFFICIENT RETROFITS IN GERMANY – TENANTS' HEATING CONSUMPTION AND RESULTING COST BURDEN

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Keywords: heating energy demand, heating energy consumption, cost burden

1. INTRODUCTION

Energy retrofits of residential buildings aim to increase the energy efficiency of buildings and reduce their carbon emissions. When it comes to the cost-effectiveness of energy retrofits, the reduction of heating costs is emphasized. The German rental law allows landlords to allocate up to 11 % of the costs for energy retrofits onto the annual cold rent in order to foster energy retrofits and to make sure that the tenants profiting from the retrofit contribute to the costs (i.e. minimization of the split incentive effect, a principal-agent problem which occurs when the person profiting from energy investment is not the one responsible for the investment costs).There is increasing awareness of the fact that the financial burden for tenants due to this levy is high and the expected energy savings are often not achieved. In this case study we therefore investigate the actual financial burden for tenants after an energy retrofit while taking into account the households' individual heating consumptions.

2. THEORETICAL BACKGROUND

When analysing the influence of households' heating behaviour on the financial burden they face after the retrofit, it is important to differentiate between the calculated *heating energy demand* of the flats and the actual *heating energy consumption* of the households. Only the latter is influenced by the tenants' heating behaviour which is very heterogeneous, i.e. differing in temperature preferences and settings, ways of ventilating or attendance times [1,2].

3. DATA AND METHODS

Information on the heating energy costs and heating energy consumption has been gathered for 119 tenants of a municipal housing company by analysing their heating bills. The flat-specific energy performance rating (EPR) was generated using a flat-specific heating demand calculator [3]. The rent increase after the retrofit is assessed with information on the increase per m² provided by the housing association. In addition, semi-standardized interviews focusing on the households' heating behaviour, such as ventilation and preferred indoor temperature have been conducted with 47 households [4]. Due to the small number of cases this information however delivered no added value for the analysis of tenants' heating behaviour and resulting cost burden.

4. RESULTS

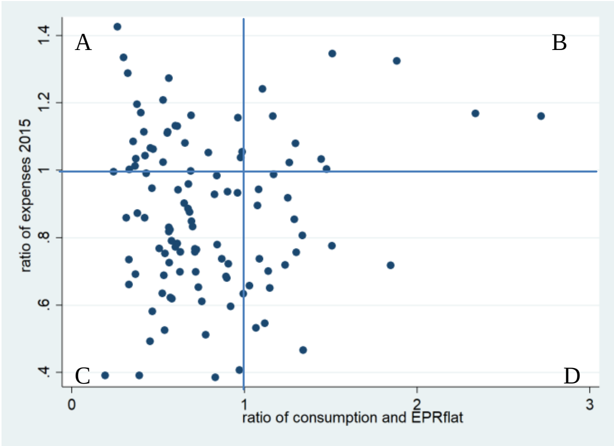

Figure 1: Comparison of the heating consumption relative to the flat-specific heating demand and the heating costs after the retrofit including a rent increase relative to the heating costs prior retrofit with base year 2015.

Figure 1 shows the financial burden for households after the retrofit, i.e. the ratio of expenses (y-axis) and the ratio of consumption (x-axis) determined by the households' heating behaviour. The horizontal baseline is a marker for heating expenses before retrofit equalling the expenses for both heating and cold rent increase after retrofit. A *ratio of expenses* below 1 therefore indicates that households are better off financially after the retrofit. The vertical baseline is a marker for household energy consumption equalling the predicted energy performance rating. A *ratio of consumption and EPRflat* below 1 hence indicates that households consume less energy than predicted by the EPR. Our findings show that one third of the households face increased costs post retrofit (fields A and B). Moreover, households in field A are not only worse off financially but also consume less energy than predicted by the EPR. This can be traced back to the fact that economizing households had already been saving on heating energy before the retrofit and therefore had had lower overall costs compared to households with higher consumptions – the stipulated rent increase due to the retrofit however is the same for everyone regardless of individual consumption.

5. CONCLUSION

In summary, our analysis shows that the lower the initial heating energy consumption, the lower also the financial benefit for households after a retrofit. Considering the goal of reducing primary energy consumption, a policy model that is structurally disadvantaging households with low consumption rates cannot be the best tool available. We thus propose a reconsideration of the current incentive model for energy efficient retrofits in Germany taking into account the results of this study.

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TOWARDS SUSTAINABLE SCHOOL BUILDINGS: WHAT BARRIERS ARE SCHOOL BOARDS ENCOUNTERING IN ENGAGEMENT WITH ENERGY SERVICE COMPANIES (ESCOS)? EVIDENCE FROM THE NETHERLANDS

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Keywords: ESCos, Barriers, Analytical Hierarchical Process (AHP), School buildings

1. INTRODUCTION

Climate change has been identified as a great challenge all over the world. Promotion of low carbon energy and associated infrastructures for tackling climate change is a central task for governments worldwide. 40% of the total energy is used in buildings according to the EU report. It is necessary to improve the energy efficiency performance of buildings. Among all types of public buildings, a large number of school buildings will be in time for renovation. A reduction of up to 30% energy consumption can be realized in school buildings renovation [1][2]. Besides energy consumption, comfort also needs to be taken into consideration. A number of studies have shown that the air quality in school buildings is insufficient for a healthy environment. CO_2 levels are often too high and the air quality is low caused by insufficient ventilation. This can be improved significantly by the renovation. The market offers a range of innovative technologies for construction and technical building services, which enable users to achieve high-energy savings and improve air quality if used correctly. ESCos as an energy service company which provides comprehensive energy solutions to its customers, including auditing, redesigning and implementing changes to improve energy efficiency [3][4][5]. It often uses performance contracting which is responsible to pay the difference if the project does not provide returns on the investment. However, ESCos are not often accepted by school boards even with promotion from the government. Considering school buildings, which have low financial capacity and poor air quality work environment with high energy consumption, ESCos seems to fit the school building retrofitting process best. It can guarantee energy savings and/or provision of the same level of energy service at lower costs. However so far, only a few school buildings in the Netherlands applied the ESCos. This paper first explored the barriers that obscure school building energy efficiency improvement in general and ESCos implementation particularly in school buildings in the Netherlands. Then, it analyzed which strategies should be used to resolve these barriers and promote ESCos in school buildings retrofitting projects.

2. METHODOLOGY

Firstly, based on a literature study, common barriers in ESCos projects will be identified. To identify whether the common barriers summarised in the literature review also applies to school buildings in the Netherlands, a qualitative interview method is applied. In total 9 interviews have been conducted including 8 face-to-face interviews and 1 phone interview. Different school communities were approached all over the Netherlands. The interview is organized in a semi-structured way. The prepared questions were sent 3-5 days before the interview. The questions can be segmented into 6 parts which are 1) The role of the interviewee; 2) energy saving situation at this moment; 3) willingness of taking energy saving measures; 4) knowledge of ESCos; 5) collaborations with other schools and 6) financial resources. Each interview took around 1-2 hours. All interviews are conducted in November and December 2017. Based on the interview results, important barriers for applying ESCos in school renovation projects are recognized.

In order to understand the importance of these barriers in the decision-making process of school buildings retrofitting with ESCos approach, Analytical Hierarchical Process (AHP) is applied. The method is used to structure the multi-attributes problems into a hierarchy of interrelated elements [6][7]. Considering school building retrofitting is a multi-stakeholder problem, 55 stakeholders were invited to participate in the questionnaire. Through pairwise comparisons and based on the knowledge from all stakeholders, a scale of barriers priority is generated. Solutions for resolving these barriers and promoting ESCos are suggested in the end based on the AHP results.

3. PRIMARY RESULTS AND DISCUSSION

We found that stakeholders all agreed that it is needed to reduce the energy consumption of school buildings. However, there are a few main barriers which slow down the process. First, schools do not own these properties (buildings) but the governments do. According to the Dutch law, large investments are not allowed by school boards. Second, schools receive a lump sum payment from the government to keep the school buildings operational. There is no extra financial support from the government for school building renovation. Third, many schools did not monitor their energy consumption and air quality. Moreover, they did not set any target for energy saving and/or air quality improvement. Last but not least, they have limited knowledge of ESCos or any other energy saving measurement method. They over-estimate the difficulties of implementing ESCos. Considering the budget limitation, feasibility, manpower, and limited knowledge, they rather wait for the planned replacement of the building equipment or elements. The aspect of risks when applying ESCos also highlighted by many stakeholders, which includes long-term contracts, keep control/fear of losing control and unforeseen circumstances.

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HOW DO INVESTORS CHOOSE INTERMEDIARIES FOR ENERGY EFFICIENCY REFURBISHMENTS?

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Keywords: Energy efficiency, Behaviour, Information, Communication, Laypersons, Experts

1. INTRODUCTION

In Germany, the refurbishment rate for more energy efficient buildings is lagging behind expectations. It is therefore important to understand which factors influence the decision of house owners to invest in energy efficiency measures. A group of actors which play an important role in this context are intermediaries [1][2], because they can function as change agents for laypersons in the highly complex field of energy efficiency refurbishment and can thus have a great influence on the final refurbishment decision. Despite their crucial role, research on the interaction of intermediaries with investors in the context of energy savings is scarce [1], and presents an “overlooked opportunity” for research [3]. Therefore, we analyse the interface between intermediaries (craftsmen, architects, energy advisors) and private house owners. The focus of the empirical analysis is the first occasion of contact, the search for suitable intermediaries and the decision of the house owner who to engage [4], as the choice of an intermediary can already influence the outcome of the refurbishment [5] and it has been shown that the influence of intermediaries is greatest before the actual installation phase [3]. It will further be analysed if choice criteria differ for different groups of intermediaries, especially for energy advisors, who have been shown to face acceptance problems among investors [6]. The results of the analysis can help to better understand the role of intermediaries for energy efficiency measures and identify possible levers for targeted policies.

2. METHOD AND RESULTS

First, interviews with house owners and intermediaries were conducted. The house owners (n=9) had conducted a variety of energy efficiency measures (installation of PV systems, change of heating system, insulation of facade, change of windows) and were asked about their decision process, experience during the refurbishment phase and their interaction with intermediaries. The intermediaries (n=12, craftsmen, architects and energy advisors) were interviewed about the decision process of their customers, their experience from consultations on refurbishments and their influence on the decision process of the investors. The interviews were supplemented by an online questionnaire (n=167) which aimed at uncovering participants’ experience with energy efficiency refurbishments and interaction with and trust in intermediaries.
How do investors search for intermediaries? Instead of detailed research on intermediaries, many investors reported that they relied on craftsmen or architects they were already acquainted with. Only if no suitable intermediary was found among their personal network, they used other sources. The interviewed intermediaries supported this finding, they reported that most clients knew them before or that they had been recommended. Availability was a further criterion which determined that those intermediaries were chosen which simply had time to be engaged. Concerning energy advisors, the investors had been contacted by them directly during a local campaign or energy advisors had been recommended by the architect. Energy advisors reported that advertising (e.g., at their offices, or via stalls at local trade fairs) had also attracted clients.

According to which criteria do investors choose intermediaries? It was important for investors to have only one point of contact ("everything from a single source"). Price was also a criterion, although not the most important. The technical competence was mentioned as a further reason to engage an intermediary (e.g., experienced with eco-friendly refurbishments), as well as a general impression of competence. The quantitative analysis showed that indeed, professional suitability was the most important criterion for choosing an intermediary. Trust was a decisive factor for those who had chosen intermediaries as a result of recommendations from acquaintances. The advice by acquaintances was the second most important criterion for choosing an intermediary for those participants who had not yet engaged in energy efficiency refurbishment. The intermediaries also considered a trustful relationship important for the motivation of investors to finalize the measures. The intermediaries reported that they actively work on a good relationship with their clients by gaining an understanding what is important for them. One reported that, as a result of this, he had been working with the same client for decades.
Do choice criteria differ for different groups of intermediaries? On the basis of the interviews, it was found that energy advisors are chosen based on different criteria and also make contact to clients in different ways than architects and craftsmen. Because they cannot rely on trust based on personal contacts and recommendations as much (half of the respondents did not know energy advisors from their personal network), they have to find other ways to convince clients, such as, e.g., the membership in an official network, which, according to the quantitative analysis, is more important for choosing energy advisors than for architects and craftsmen.

3. CONCLUSION

Technical competence and trust play a major role for the choice of an intermediary, and trust can even overrule price. Trust, for craftsmen and architects, is established via personal experience or recommendations of trusted persons. Based on the findings, the difficult role of energy advisors [6] can partly be explained by the lack of those sources. The findings are insightful for the explanation of the special role of the energy advisors and they support the thesis that intermediaries are an important target group for policy measures. They can have a great influence on the diffusion of energy efficiency measures based on the trustful relationship they have with their clients. Serving as first insights into the contact-phase between private house owners and intermediaries, the results need follow-up studies to clarify their generalizability.

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A BOTTOM-UP APPROACH FOR SYSTEM INTEGRATION OF ENERGY INFRASTRUCTURES TO SUPPORT ENERGY FLEXIBILITY

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Keywords: Human-in-the-loop process control, system integration, energy infrastructure

1. INTRODUCTION

Energy consumption in buildings accounts for up to 40% of total energy consumption. In an effort to improve energy and environmental sustainability, buildings have been the target of a number of energy demand reduction strategies. Occupant behaviour in buildings is a key factor that significantly influences the energy consumption of buildings. Whilst researchers have focused considerable effort into understanding and developing strategies that address the impact of occupant behaviour on building energy consumption, the high-energy demand of buildings is considered a useful source of demand-side energy flexibility for the smart-grid. In addressing the influence of occupant behaviour in buildings. In harnessing the energy flexibility potentials of buildings, building energy management systems play a vital role. Traditional building energy management systems are however static and lack input of dynamic factors such as occupancy as well as occupant preference. In addition, traditional building energy management systems are limited in their ability to optimally coordinate the use of buildings energy flexibility without compromising occupant comfort on the room-level.

2. METHODOLOGY

Traditionally top down organized energy supply in electricity and gas networks have to cope with decentralized renewable energy production. Energy consumption could be predicted quite well on macro level, and large power plants pre-schedule their power generation based on this. However an increasing share of decentralized energy generation on micro level introduces growing complexities and uncertainties that have to be factored in operations. Using the flexibility within energy generation, distribution infrastructure, renewable energy sources and the built environment is the ultimate sustainable strategy. Clearly the energy demand characteristics of buildings, available from Building Energy Management Systems, are valuable information for grid optimization. Smart control of energy consumption and generation inside (naoGrid) and around buildings (microGrid) can provide major contributions to address the imminent energy problems within the total energy infrastructure, the SMART Grid. These problems are partly caused by the use of decentralized renewable energy sources. Breakthroughs need to be realized in the field of process control of heat, cold and electricity storage, demand and distribution. New process control strategies are needed for improving the energy interaction within the building, its environment and the energy infrastructure by effectively incorporate the occupant's behaviour. This research explored the use of increased sensor data and computational support for enhancement of energy management and energy flexibility in buildings. Specifically, the research focuses on the application of fine-grained information on building occupancy as well as multi-agent systems in enhancing the performance of traditional building energy management systems in office buildings, see Fig.1 [1]. This forms the basis for Human in the loop process control, see Fig 2.

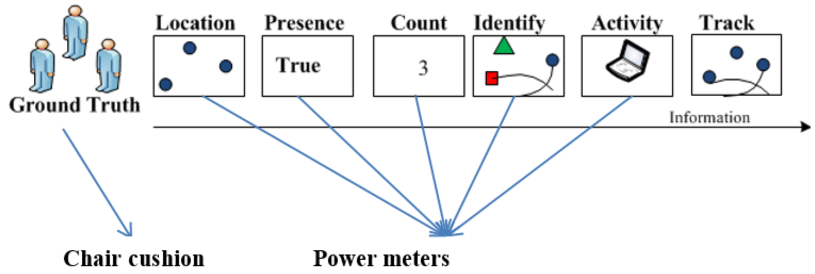

Figure 1: Fine grained user information [1]

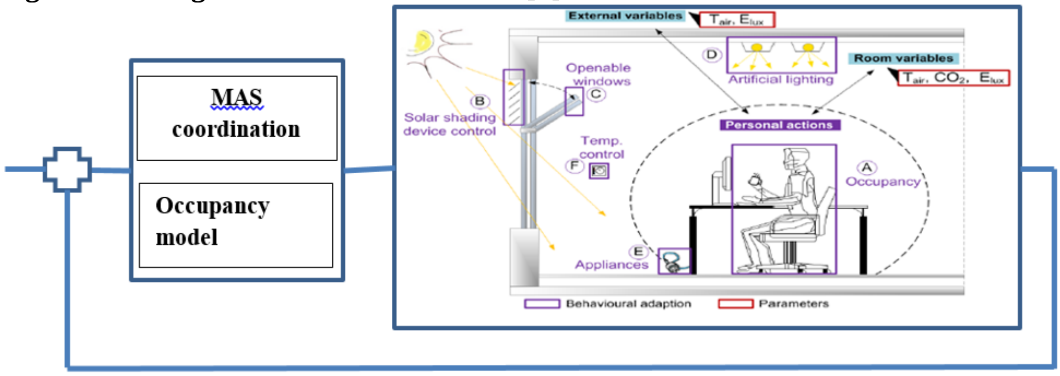

Figure 2: Control schematic Human-in-the-loop approach

3. CONCLUSIONS

Field experiments were conducted in an office building to evaluate alternative methods for obtaining fine-grained occupancy information that enhance energy management [1, 2]. Furthermore, a multi-agent system coordination framework was developed and assessed in the test-bed office building for coordination of occupant behaviour on the room-level and the building's energy flexibility. Next step is to define Neighborhood Energy Management systems and to look for possibilities of a virtual coupling with the SCADA systems of the Grid operators. Grouping energy demand of end-users and local renewable producers in neighbourhoods will enforce end-user involvement and automated lad shifting which greatly improves the efficiency of advanced energy management. This allows maximizing the utilization of flexible demand resources within neighbourhood and forms a bottom-up approach for system integration of energy infrastructures starting from the user to support the Smart grid.

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BETTER SAVED THAN SPENT? THE CARBON FOOTPRINT OF SAVINGS ACROSS SOCIOECONOMIC GROUPS

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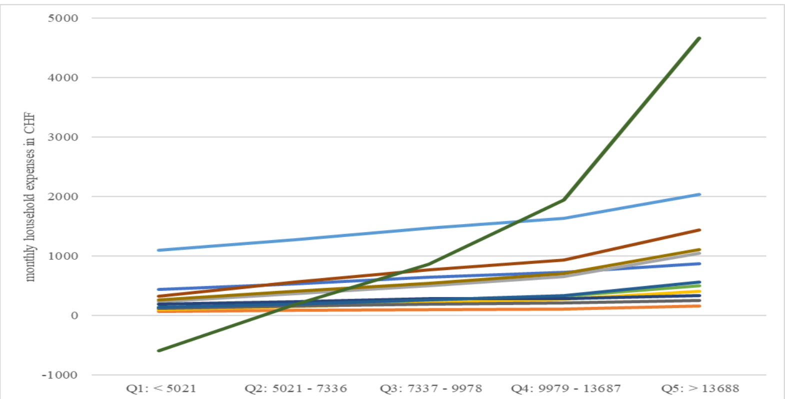
Keywords: Carbon footprint, Distributional impacts, Household savings, Rebound effects

To maximise the effectiveness of climate and energy policies designed to mitigate climate change, a clear understanding of the size and the cause of emissions from both production and consumption activities is paramount. We focus on the latter and in particular on household expenditures. There is a great variety of research addressing the environmental impacts of households, ranging from spatial differences [1] to income disparities and affluence [2] or individual consumption categories [3]. Meanwhile, one impact appears to have largely been overlooked, namely the carbon footprint of the share of household expenditures that is not spent: (monetary) savings, which comprise a key contribution to financing capital investment [4]. Figure 1 shows how household savings, after mandatory transfer (i.e. pension fund contributions), compare with other expenditures and across income groups [5]. The highest quintile saves exponentially more than the second highest and the bottom quintile even accumulates debt. Moreover, the difference between savings amongst the most and least affluent categories is much more pronounced than in any other expenditure categories.

Figure 1: Consumption Expenditure Categories and Savings Across Income Quintiles in Switzerland



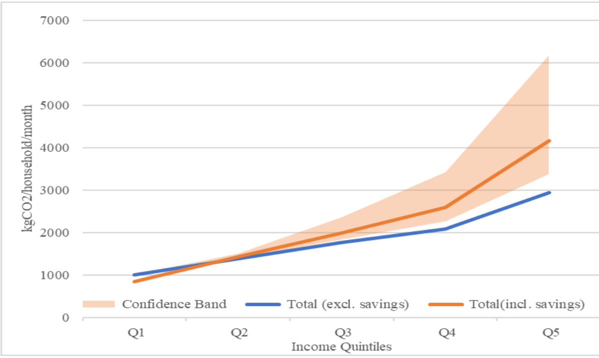
Rationale for study

This research investigates the possible implications of accounting for carbon emissions from household savings in three ways: (1) We analyse the impact of savings on the relationship between carbon emissions and income. In Europe, different income groups tend to contribute non linearly to total carbon emissions [6], potentially more so when accounting for the carbon intensity of savings. (2) We also test the hypothesis that when monetary savings from energy efficiency improvements are kept in green investments, a potentially significant reduction of emissions and rebound effects can be achieved, as postulated by [7]. (3) We further build on the current debate between weak and strong sustainable consumption, or efficiency vs. sufficiency [8] and provide a new perspective on whether any disposable income is better saved than spent from an emissions reduction standpoint.

Method and Results

In international comparison, households in Switzerland have high savings rates with large differences between income groups. Thus, we compare the total Swiss emissions from twelve consumption categories [3] to the total emissions from consumption *plus* the ones from savings. Carbon intensities of investments are used as proxies for the intensities of household savings on the basis of the savings equal investment hypothesis. We use a range of estimates from the literature, which comprised of carbon intensities of total investment, private investments and representative funds. Preliminary results are shown in Figure 2. Including emissions from savings accounts could indeed potentially increase the carbon footprint of almost all income groups, particularly the more affluent households. As shown by the spread of the confidence band, there is a large uncertainty due to the different estimates of carbon intensities.

Figure 2: Relationship between Carbon Emissions and Income Quintiles



Policy implications

Emissions from investments are technically accounted for in financial activities or capital formation and households may have limited power over where savings are invested into. Nonetheless, we conclude that in the case of Switzerland, the carbon footprint of household savings deserves more attention given their magnitude and potential impacts. The challenge is therefore to identify the emissions for which households are responsible through savings account and how this can be influenced by different income groups. Especially, since the results above indicate that money held in savings accounts by affluent households provides substantial potential to reduce their footprint, as well as increase investment in energy efficiency measures. This would also offer possibilities to reduce the rebound effects of household consumption and thus strengthen the rationale for energy efficiency policy. Finally, we argue that households' disposable income might be better spent, especially on energy efficiency measures, than saved in light of the carbon footprint of resulting investments.

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